Materials & Methods
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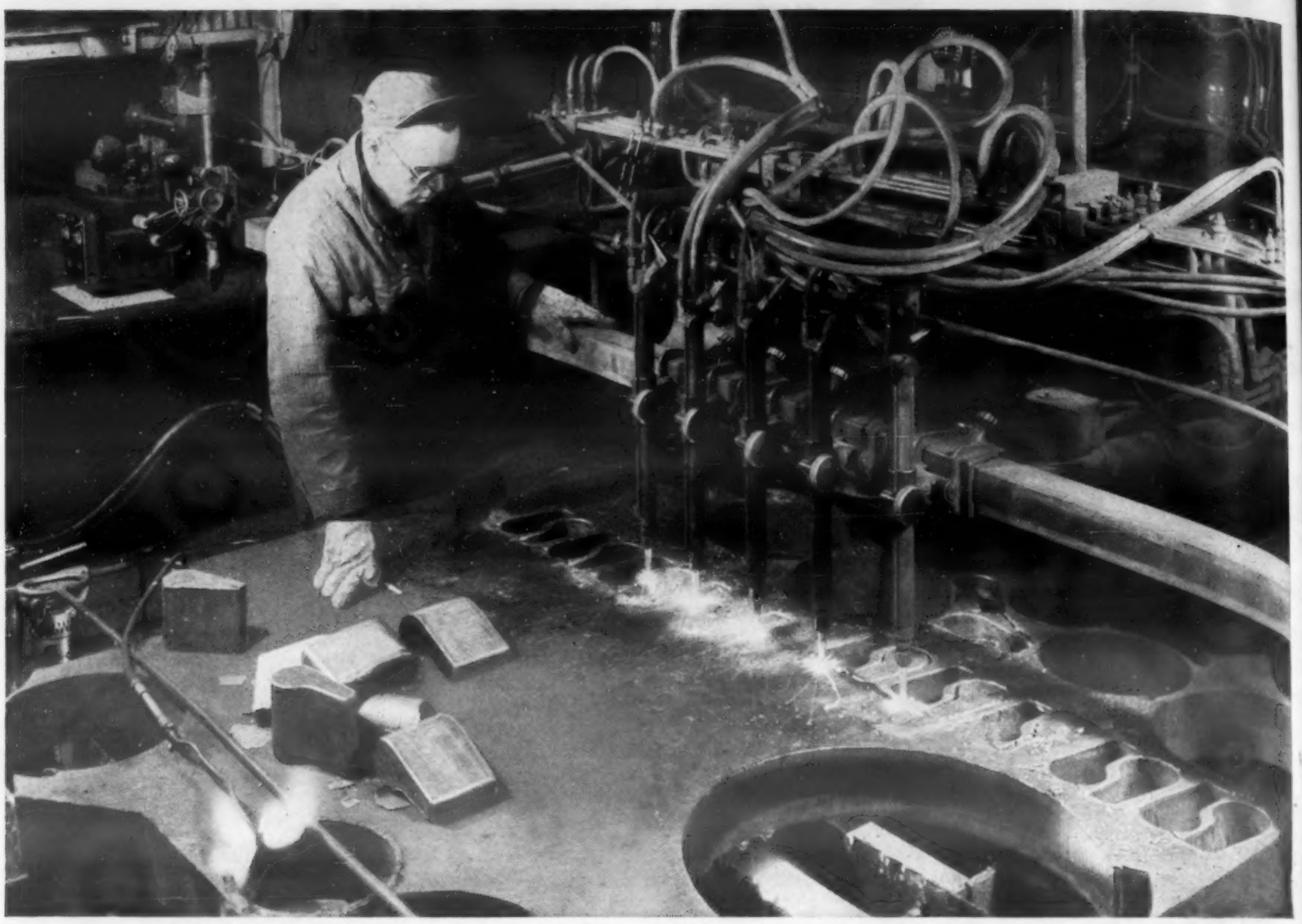
Established in 1929 as Metals and Alloys.



The metal box, upper left behind operator, contains electronic tracing device which follows sketch and guides cutting torch.

New Electric Eye Machines Speed Ryerson Cutting Service

The multiple-torch gas cutting machine shown above is one of eleven recently installed in Ryerson plants from coast to coast. Equipped with an electronic eye tracing device, these remarkable new machines cut the most intricate shapes swiftly, accurately. Time spent in preparing wood and metal template making is eliminated. Instead the electric eye follows a simple sketch or blueprint within plus or minus fifteen-thousandths of an inch!

Many manufacturers are saving time and effecting substantial economies through the use of Ryerson flame-cutting. With electric eye machines rounding out a complete flame-cutting service, your Ryerson plant produces an endless variety of shapes from strong rolled steel. To mention only a few—circles, rings, wrenches, flanges, crankshafts, weldment parts, cams—many more. The result: clean, accurate edges whether mild steel, high carbon, alloy or stainless steel is used. And your Ryerson plant can produce hundreds of pieces to the same pattern with almost die-cut uniformity, from steel plate up to 15-in. thick.

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News Digest

New Type Spring Easier To Deform as Load Is Applied

Prestressing the steel from which it is made is the secret behind a new type spring developed by W. J. Cook of Hunter Spring Co., Lansdale, Pa. This unique spring deforms with increasing ease as heavier loads are applied.

Ordinarily a coil spring becomes more difficult to pull as it extends. The Neg'ator, as the new spring is called, works contrary to the established principle and resists less, the more it is deformed from its normal condition.

This unusual reaction is achieved, Mr. Cook explains, by prestressing each successive increment of length of a flat strip by a predetermined amount. In its relaxed state the spring forms into a tight coil. When used the Neg'ator unwinds much like a tape measure.

Uses predicted for the new type spring include electric toasters, delicate instruments, hose wrappings, automatic coiling devices, extension or coil springs, and many others. A range of action up to fifty times any original dimension is credited to the device. Too, the Neg'ator is said to work around corners with equal efficiency.

Museum Exhibit to Tell Story of Aluminum Production and Use

Sponsored by the Aluminum Co. of America, an exhibit has been opened in the Chicago Museum of Science and Industry to bring to the public the story of aluminum from ore to consumer. Paintings, photographs and recorded narrations combine with visitor-operated exhibits to dramatize the light metal. In the latter group are devices to show in an easily understood way the physical characteristics of aluminum, including lightness, electrical conductivity, reflectivity of light, and radiant heat properties.

Samples of aluminum applications form a large part of the exhibit. A sectionalized aluminum home shows architectural uses; models of planes, trains and ships illustrate transportation applications; sporting goods and home appliances picture still another group of applications.

Exhibits and displays are augmented periodically by special lectures and demonstrations as well as two sound motion pictures.

An Announcement

The editors of MATERIALS & METHODS have long felt the need for a section wherein they could bring to their readers news of a nature that did not fit readily into existing departments in the magazine. This section, introduced in the September M & M, is intended to remedy that deficiency.

In this location each month you will find reports on developments in this country and abroad which we feel will be of interest to our readers. The items presented here will be a digest of news presented by the companies or organizations concerned, through field trips of our editors, from papers presented before technical meetings, and through a careful perusal of foreign technical periodicals.

Since, to some degree, the *News Digest* will duplicate much of the material which formerly appeared in the *Digest* section of this publication, that department is now being eliminated.

The *Editorial* page, formerly in this location, has been shifted to the page facing the inside back cover in the space formerly occupied by *The Last Word*.

These changes are being made in a sincere effort to provide our readers with materials that will be helpful and useful. Conversely, when a department or feature seems to have outlived its usefulness, we shall remove it to make way for more timely material.

—The Editors

Stability of AISI Alloy Steels To Be Reported On in Paper

Two metallurgists of the National Tube Co. are to report on changes in microstructure, impact and hardness properties, and oxidation characteristics of typical AISI alloy steels exposed to high temperatures for long periods. A. B. Wilder, chief metallurgist of the U. S. Steel Corp. subsidiary, and J. O. Light, chief metallurgist of the Lorain Works of the tube company, are to present the paper.

Their report will discuss steels in the welded and unwelded conditions at 900 and 1050 F for a period of 10,000 hr. All steels were exposed at 1200 F for the same period, but decarburization and scaling were too severe to permit evaluation of properties.

AISI alloy steels are of the ferritic type and were developed primarily because of their response to heat treatment. They are widely used in the quenched and tempered condition. The alloys contain manganese, molybdenum (usually under 0.30%), nickel, chromium (usually under 1.75%), silicon, vanadium, and often other alloying elements. In the work being reported on, two carbon levels were investigated in the 3100, 4100, 4300, 8600, 4600 and 6100 series; a single carbon level in the 2300, 2500, 3300 and 4800 series. All steels were either normalized or annealed at 1650 F before exposure.

Conclusions to be reported include:

(1) The steels oxidized and decarburized appreciably after 10,000 hr. at 1200 F. (2) AISI nickel and nickel-molybdenum steels graphitized at 1050 F. Graphite was also observed in the AISI 2320 and 4640 steels after exposure at 900 F. (3) The AISI steels containing chromium did not graphitize after 10,000-hr. exposure at either 900 or 1050 F,

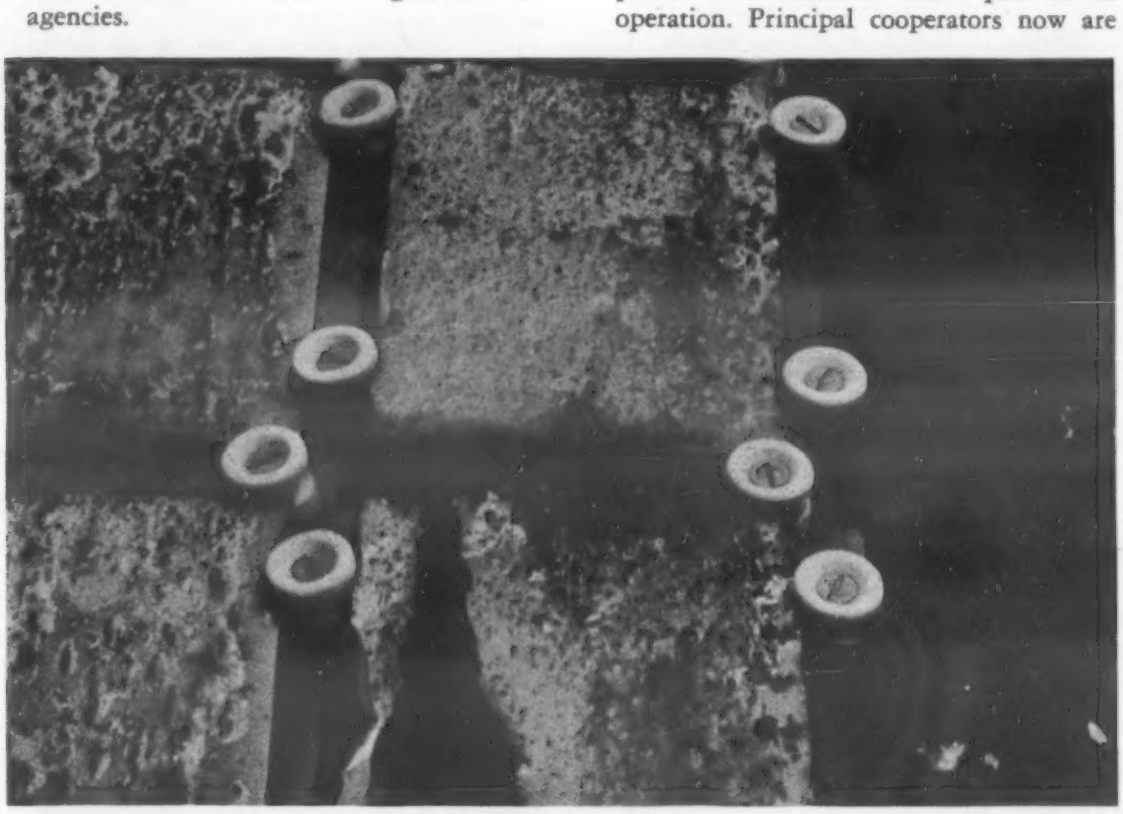
(Continued on page 54)

even though an appreciable amount of aluminum was used in the deoxidation practice, and, in certain instances, large amounts of carbon were present. (4) The AISI steels containing chromium were more stable microstructurally than those without chromium. The chromium-vanadium and chromium-molybdenum steels were the most stable. (5) The steels investigated were not embrittled by exposure at the elevated temperatures. (6) The hardness of the steels investigated was, in general, slightly decreased after exposure.

More Than 15,000 Samples Tested At Kure Beach Corrosion Station

The corrosion test station at Kure Beach, North Carolina, which started as a modest testing site for the products of a few cooperating companies, has now developed to the point where a wide variety of materials and products are tested for many manufacturers as well as government agencies.

Kure Beach is the result of an early effort to compare low alloy steels with carbon steels as far as corrosion resistance was concerned. The original station was established in 1935. Since 1940, when the facilities were enlarged, other companies have taken an active part in its operation. Principal cooperators now are



These are samples of electroplated steel on the test rocks at Kure Beach. By means of such tests, better standards are arrived at.

The present station is capable of testing materials against sea water attack as well as against attack from salt laden atmospheres. At present there are more than 15,000 metal specimens in the atmospheric test racks alone. In addition, there are many samples kept under water permanently, and other samples undergoing cavitation tests and operational tests.

Dow Chemical Co. and Carnegie-Illinois Steel Corp.

No comparative tests are conducted at Kure Beach. That is, no company can take its product and that of a competitor and test them concurrently. All data uncovered, regardless of sponsor, becomes available as scientific information, with the possible exception of some work done for the Navy or other branches of the Military establishment.

As an example of how these tests can help the public, there can be cited the test rack devoted to electroplated coatings. In this area many different samples are exposed under identical conditions. The samples vary as to the combinations of metal comprising the coatings and as to the thicknesses of the various coating metals. The data thus uncovered will serve as a basis for electroplating specifications for certain types of applications.

Also of interest are racks on which are tested samples of various materials for window screening. So that tests will be conclusive, identical samples are mounted so they will be exposed to all the elements at all times, while others of the same materials are mounted so they will be shaded from the sun and from mild rain storms.

Of all the materials tested, titanium seems to have the highest resistance to both sea water and atmospheric corrosion. Samples tested at Kure Beach for several months do not show any signs of corrosion.

Die Cast Aluminum Auto Door Forecasts Future Body Uses

The inner frame of an automobile door is now being successfully die cast from aluminum and is expected to lead to further use of die castings in automobile bodies. The die cast frames weigh 13⅜ lb. before trimming and measure 43⅜ in. by 33 in. Kaiser-Frazer Corp. and Doehler-Jarvis Corp. cooperated in designing and producing the large die casting.

From the production standpoint, here are the advantages said to accrue from the new application of die casting:

- A reduction in weight of 8.6 lb. per door. (34.4 lb. per 4-door sedan.)
- Elimination of four steel stampings on each door.
- Elimination of at least one large welding jig.
- Elimination of a press line used to form, trim and flange steel stampings.

Clay P. Bedford, executive vice president of Kaiser-Frazer, states that at present price relationships the cost of all-steel doors and aluminum-steel doors would be almost identical.

Kaiser-Frazer has not announced when it will apply the new type door to its line of automobiles. Development work

up to this point has been directed toward establishing the feasibility of using molded body sections. If applied to any extent, Kaiser-Frazer officials say, die casting of large size could substantially reduce the weight and perhaps eventually the cost of automobiles.

U. S. Steel to Recover Ore from Blast Furnace Dust

Five new plants are being planned by the U. S. Steel Corp. to process powdery iron ore to usable size and recover iron from blast furnace flue dust. Through these facilities, U. S. Steel expects to add 1,800,000 tons of high grade ore to its furnaces without requiring an equivalent increase in iron mining.

Sintering plants will be erected at Gary, Ind., South Chicago, Ill., at the Carrie Furnace and Edgar Thompson works of the corporation in the Pittsburgh district, and a fifth at the works of the National Tube Co., McKeesport, Pa. The sintering plants will recover substantial quantities of iron values present in flue dust and in sludge recovered from dust catchers and gas washers of modern blast furnaces. Flue dust has an iron content of about 50%.

Some U. S. Steel plants already have sintering facilities, but dust is recovered at a rate faster than can now be handled. Last year existing sintering plants produced at a rate of 3,400,000 tons of sinter a year. Sinter can be added to blast furnace charges utilizing lower grade ores and aid in the production of quality steel.

Report on Foundry Gating Systems Available from U. S.

High-speed motion picture photography was used by the Naval Research Laboratory to study the actions of gating systems in common use today. The investigation showed that no gating system used entirely prevented turbulence in molten steel, but that whirl, riser and horn gates were particularly ineffective.

In making the studies, steel was poured at 3000 F with 64-frame per sec. movies photographing the discharge of molten metal into the mold cavities. Metal flow through sprues was studied on pictures taken at 1000 frames per sec.

Complete reports can be ordered from the Library of Congress in photostat form ($2.50) or on microfilm ($1.75). The report is No. PB97403, and its title is "Gating Systems for Metal Castings."

Zinc Consumption Down in May Bureau of Mines Report States

Slab zinc consumption in the United States in May declined 3% below April and 10% less than the 1949 monthly average. The Bureau of Mines report states that May's consumption was the lowest since February 1946. Inventories of consumers were down 16% from April 30. The largest decline in user groups was in those uses involving zinc-base alloys. They include die castings, stamping dies and zinc alloy rod and slush and sand castings. These fields required 100 less tons in May than in April. Total consumption of zinc during May was 51,725 tons.

Bi-Metallic Brake Drums Show Promise in Automotive Use

Charles E. Stevens, Jr., chief engineer, Al-Fin Div., Fairchild Aircraft & Airplane Corp., presented a paper on bi-metallic brake drums at the West Coast meeting of the SAE in Portland, Ore., Aug. 15 to 17. The brake drum is composed of aluminum cooling fins integrally bonded to a cast-iron liner by the Al-Fin process. This, in effect, makes the assembly a heat exchanger rather than a heat reservoir, as is the all cast iron drum, Mr. Stevens said.

Brake drums of the type described have been tested on buses, trucks and midget racing cars. In addition to providing weight reduction of from 30 to 50%, the aluminum-cast iron brake drums provide longer life and require less frequent adjustment of braking systems.

Bi-metallic brake drums are expected to find wide use in the bus and truck fields where brakes are now subjected to considerable overheating.

Protective Coating Forms Insulator Against Flames and High Heat

A new protective coating, not yet commercially available, is said to retard fire by creating an inch-thick insulating substance when exposed to flames and extreme heat. Chief industrial use anticipated for the coating by the Sherwin-Williams Co., its developer, is for such surfaces as aircraft interiors. For the present the coating is known simply as "Coating X."

The coating material is a powder thinned in water which resembles clear varnish in appearance. Conventional finishes can be applied over this coating. In a laboratory test, a wooden panel coated with the material was subject to blow-torch flames for 25 min. After the thick, spongy mass was removed from the wood surface, it was found that the wood had not even been charred.

United Nations Meeting Studies Conservation of World Resources

Representatives of more than 70 nations met at Lake Success for the United Nations Scientific Conference on the Conservation and Utilization of Resources on Aug. 17. The sessions continued for three weeks.

More than 500 papers were discussed at 60 section meetings. Specialists reported on their experience on subjects concerning the conservation and use of mineral, fuel, land, forest and marine resources.

Among the papers of interest to materials men are those on the substitution of light metals for steel and copper; conservation of lead; and, the role of protective coatings in the conservation of metals.

Ford Technicians Develop New Metal Etching Method

Ionized atoms are utilized in a new metal etching technique developed at the Ford Motor Co. The new process, known as cathodic vacuum etching, is said to enable the taking of exceptionally clear photographs of flow lines in forgings.

In operation, the method requires that a metal sample be placed in a partial vacuum with argon. Twelve thousand volts of electricity are charged into the vacuum, creating argon ions which bombard the metal surface and knock off minute particles.

Comparison of the structure pattern produced by the best chemical etching method shows that the new cathodic treatment brings out the true microstructure of the metal with greater detail and clarity. Flow lines previously undetected in steel samples now can be clearly shown.

Plastics Exposition in March 1949

The next National Plastics Exposition is to be held next March in Chicago, according to an announcement by the Society of the Plastics Industry. Exhibits will be located on the Navy Pier, with the exposition starting Mar. 28 and continuing through Mar. 31. Dale Amos, general manager of Amos Molded Plastics Co., is chairman of the event.

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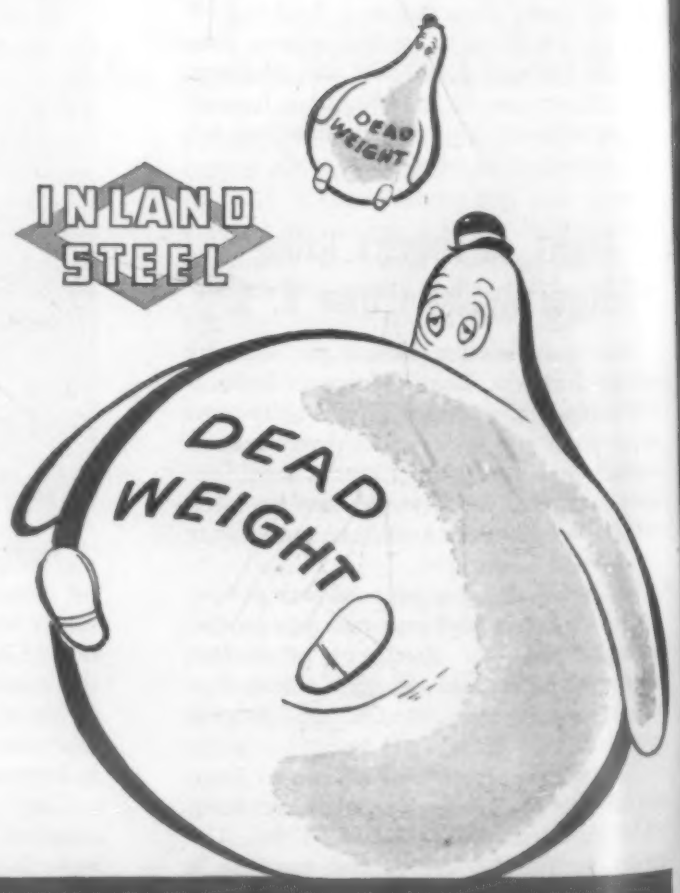

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Materials & Methods
SEPTEMBER 1949

Choice of Materials Helps Achieve Remarkable Weight Reduction in ACF Talgo Train

Materials selected for this new train permitted designers to reduce weight by 75% over standard trains and lower center of gravity by 4 ft.

by T. C. DU MOND, Editor, Materials & Methods

● Intelligent materials engineering made possible the fulfillment of design engineers' dreams in building the recently unveiled ACF Talgo train. The Talgo embodies many features never before considered in train construction and could very easily be the means of offsetting rising railroad costs.

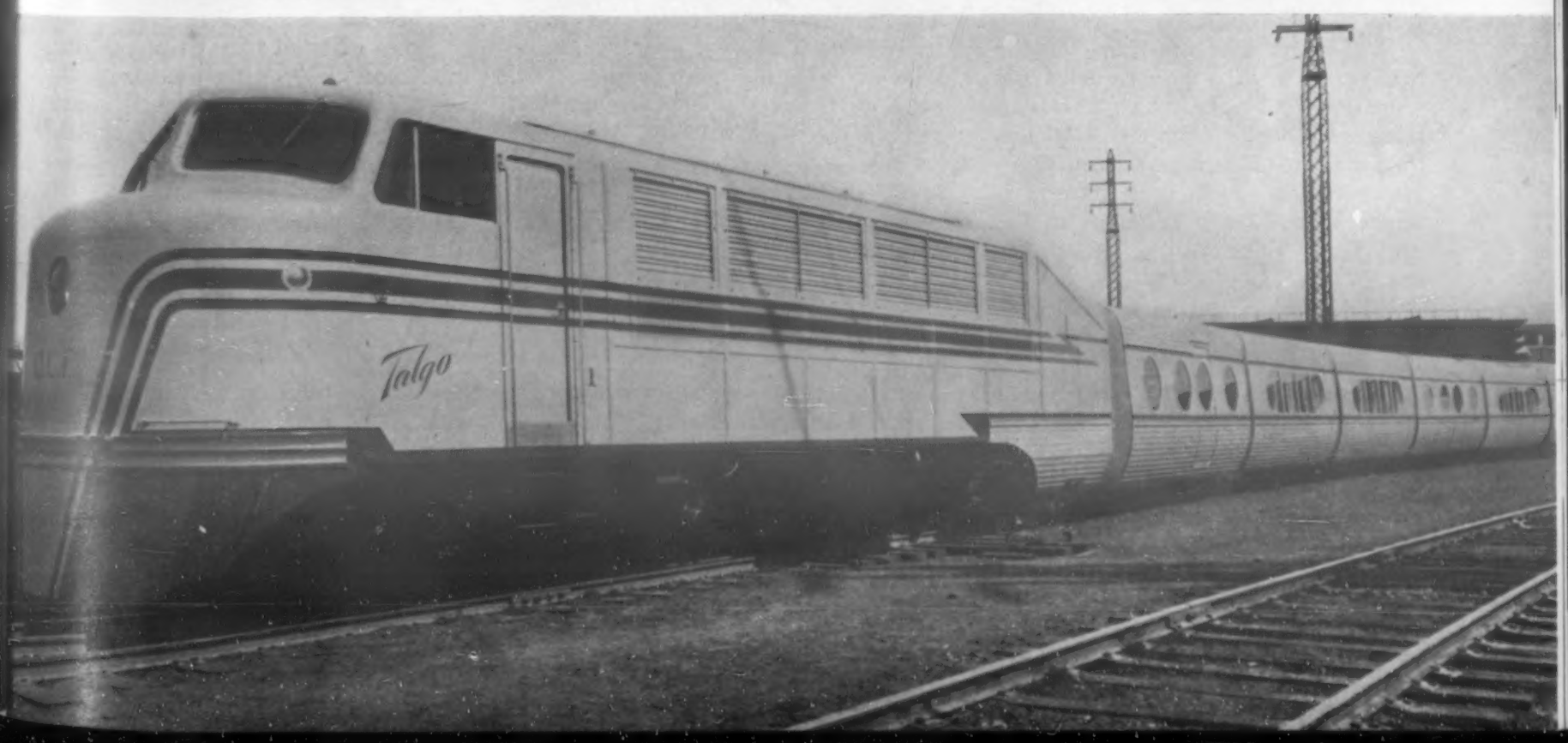
Less weight and more action was the goal of engineers working on the train. What they meant was, in effect, provide transportation with less horsepower per passenger carried.

That this has been achieved can be seen from these facts: Coach room for 64 passengers on the Talgo requires a weight of approximately 37,400 lb. This weight compares with 135,000 lb. for the normal passenger car and 110,000 lb. for the lightest standard coach previously built.

Much of the credit for the tremendous weight reduction goes to the use of aluminum for all of the coaches, with the exception of the undercarriages, light weight, high strength steel castings for load bearing members and liberal usage of aluminum-plywood sandwich materials. In addition, the design reduces the overall height of the train by a substantial amount.

The Talgo originated in Spain. Spanish engineers brought their

The ACF Talgo train represents a tremendous weight saving over typical railroad passenger equipment. The locomotive is 2 ft. lower than a standard diesel-electric, and coaches are 4 ft. lower than present day equipment. (All photos courtesy American Car & Foundry Co.)



When not attached to its predecessor unit, a coach section is supported by alloy steel dolly wheels. Coupling is accomplished through horizontal support members, which fit into the two brackets shown.

ideas here, and, in joint effort with engineers of American Car and Foundry Co., developed the present day train. The name Talgo is derived from Tren (train) Articulado (jointed) Ligero (light) Goicoecha (the inventor) and Oriol (family name of the backers). Two of the new trains are being built for service in Spain while a third is now being used for testing and exhibition purposes in this country.

When one sees the train for the first time, he is impressed with the reduction in height which has been achieved. Overall height is 4 ft. less than that of standard passenger trains. However, the most important differences are not so apparent to the eye. Their value is real, never-the-less.

In designing the train engineers sought a combination of materials and design that would permit (1) lower overall height; (2) lower center of gravity; (3) less weight; (4) higher speeds, particularly around curves; (5) lower capital investment. The result of all these would add up to reduced operating costs. On the basis of the test train, the desired characteristics have been attained.

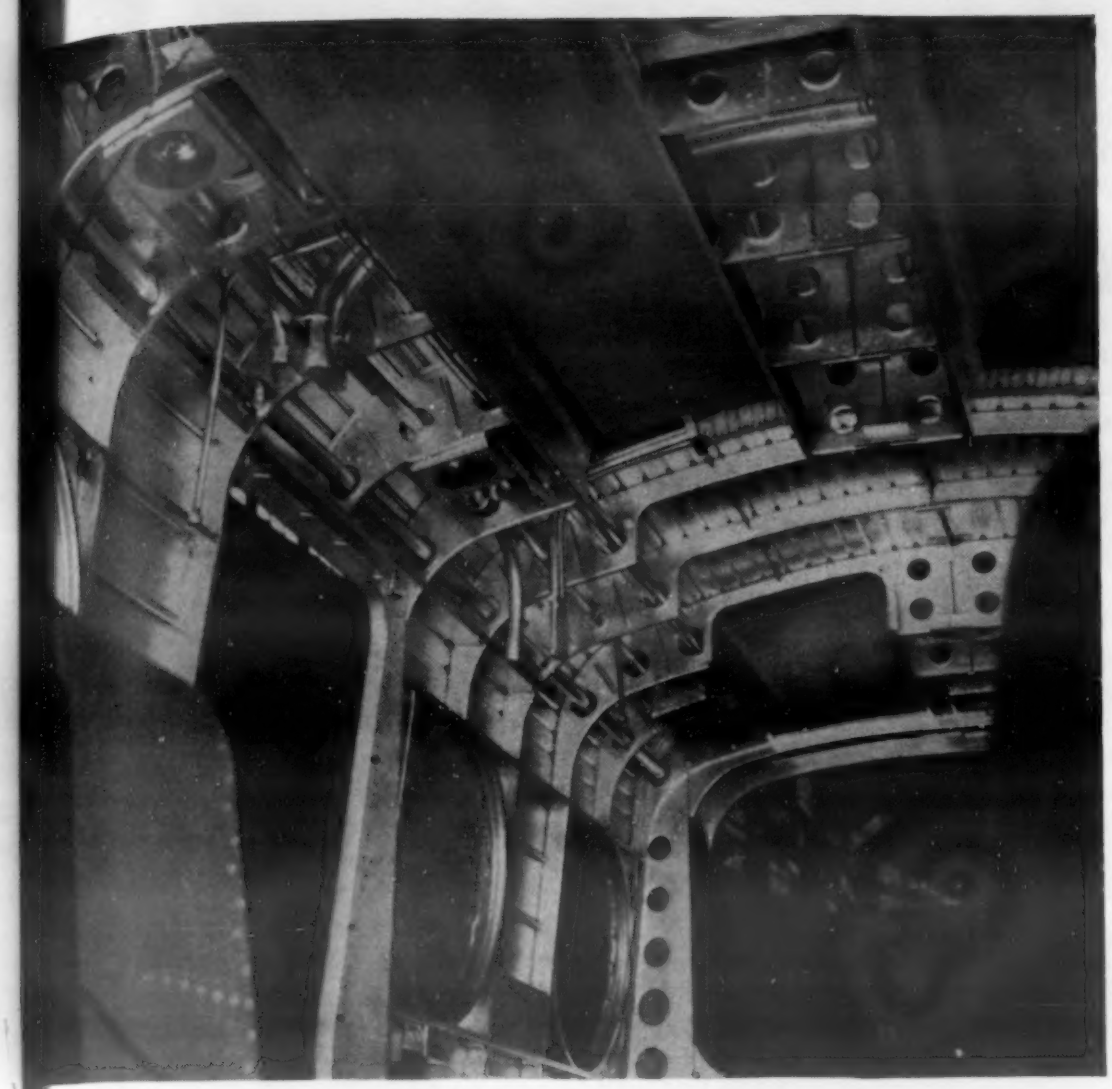
By judicious selection and application of materials, the Talgo train is able to do with 140 tons of dead weight work that would require 550 tons in a standard train. Estimates place total weight saving at 75% over standard streamliners. Above the floor line of the train, aluminum and its alloys is used almost exclusively. The undercarriage relies on high strength steel alloys to give maximum strength and minimum weight. The train also makes liberal use of Plymetl, a sandwich material consisting of plywood faced with aluminum alloy sheet. Other materials used include stainless steel, rubber, cork, and Fibreglas, aluminum bronze, plastics and phosphor bronzes.

An example of the thoroughness with which engineers sought to hold down weight can be found in the coach seats. The seats are similar to standard aircraft double seats, and because they are made of aluminum and magnesium weigh only 51 lb. each.

A standard Talgo train consists of diesel-electric locomotive, baggage unit, three coaches and an observation car. These result in an overall length of 370 ft. and provide seating for 192 passengers. Each coach consists of 4 articulated passenger units and one equipment unit. Each coach measures 100 ft. long and carries 64 passengers. The equipment car contains air conditioning equipment, control lockers, washrooms and a kitchenette.

From a design standpoint, probably the most interesting detail of the train is the undercarriage of a passenger unit. Each unit is supported in the rear by one pair of wheels. The front end is supported by the preceding unit by means of a special coupling device. The wheel suspension system plays an essential part in helping the train negotiate curves at high speeds.

The wheels are specially designed and are of built-up welded construction. The steel tire of each wheel is resiliently connected to the car by means of a rubber sandwich which helps to reduce running noises. Brake drums are fastened directly to the



Car units were constructed from aluminum alloys in three parts—the floor and two side assemblies, each of which formed half the roof.

Articulation between coach sections is achieved by means of a diaphragm, which joins the cars by means of a zipper.

wheels. Wheel springs and struts are enclosed in wells in each unit. Passengers strolling from unit to unit actually walk between the wheels and their supports. The wheels are mounted on stub axles, one on either side of the car.

Articulation between the coach units is achieved by means of rubber diaphragms. The diaphragms provide a smooth interior and exterior, but they are principally for weather protection. The diaphragms are closed by specially designed zippers with sealing lips. The zippers hold through all degrees of tension, pressure-proof the closure and provide insulation by forming a dead air space.

Materials Used

Alloy steel castings weighing from 1 to 50 lb. are used for most of the undercarriage and coupler parts. Nickel-chromium-molybdenum steels were most generally used because of their high strength properties. In addition to their strength properties, these low alloy steels were selected because engineers felt they provided wide design scope, ease of fabrication, including welding, and because they were heat-treatable.

Requirements of the steel parts included a need for high strength in light sections, high yield point and good impact resistance. In addition they had to be ductile, resist abrasion and fatigue distortion.

The most generally used alloy for steel castings is Lebanon Circle L-205 (Grade A1). The steel's composition approximates 0.30 carbon, 0.40 silicon, 0.80 manganese, 0.60 nickel, 0.60 chromium, and 0.60% molybdenum. After normalizing and tempering, this steel gives a minimum tensile strength of 95,000 psi., a yield strength of 65,000 psi. and a Brinell hardness of about 210. Two other Lebanon grades, with somewhat higher properties are used for a few other parts.

Steel forgings throughout the train are SAE 4140, with a few exceptions where SAE 4130 is used. The stub axle is made of SAE 6130 steel from 3¾-in. bar. The material is heat treated to provide a hardness of between 260 and 300 Brinell. The train's brake drums are Class 35 iron castings.

Stainless steel is used on both the locomotive and the coaches. A stainless having a composition showing approximately 25 chromium and 20% nickel is used for the main engine exhaust. On the coaches a stainless steel belt rail is used for exterior trim. This material is furnished as rolled sections.

Because of the design certain parts required special strength. Some of these are coupler parts; "dolly" wheels (to support the front ends of cars when the train is uncoupled); mounting brackets and side shock strut forks. All these are alloy steel castings. Springs are SAE 6150 spring steel, a chromium-vanadium alloy. The spring stock is heat treated to a Rockwell C hardness of 48 to 52 and tensile strength of from 230,000 to 260,000 psi. The stock is then centerless ground.

Aluminum, by volume and weight, is the most widely used material in the Talgo. The light metal is used in most of its available forms, including sheet, plate, castings, forg-

ings and extrusions. The U-shaped center sill of each unit is an extruded section 5½ in. deep. Cross-bearers, floor beams and floor stringers are Z sections. Side sills are two parallel extrusions, one assembled with the under-frame and the other with the side assembly. The car roof is beaded aluminum alloy sheet. A fake floor is riveted to the underframe.

Aluminum used for the Talgo's skin is 24ST sheet, 0.051-in. thick. The roof and lower car sections of the coaches use the aluminum with longitudinal beading. Sheet in the window area is flat. The ⅜-in. beading adds considerably to the aluminum's rigidity.

Z-sections which are rolled to form the underframe longitudinal and transverse members are also 24ST aluminum. The same alloy, press-formed, is used for carlines, connections, etc. Most of the sheet for the latter purposes is 0.091-in. thick.

Alloy 14ST is used for most of the smaller extrusions. Main side sill members, angles and additional side sill members are typical of such extruded parts. However, the U-shaped extrusion which forms the centersill is made of 75ST alloy.

Aluminum forgings are divided as to the alloy used, with the lion's share being of either 75ST or 17ST. Aluminum sand castings use an alloy approximating the specifications of ASTM B26-48-T (C-1). This material is used in a condition resulting from heat treatment #2 which gives it a tensile strength of 32,000 psi. minimum and 22,000 psi. minimum yield strength.

How effective aluminum has been in reducing weight can be demonstrated in the train's air conditioning system. That portion of a system in modern trains which is carried by a standard 75 lb. passenger car weighs about 16,000 lb. In the Talgo, by using aluminum for duct work and wherever else possible, the air condition equipment for each complete coach weighs 1,806 lb.

The aluminum sheet covering of the cars is applied as a stressed skin, such as for aircraft use. Also suggestive of aircraft practice is the use of boxed sections, where necessary. There is no break at the eaves, since hydraulically pressed sections form one piece from side sill to centerline of the roof. Combination side posts and carlines form the unit's cross section.

The car floors consist of ½-in. Plymetl. Car ends, where partitions are necessary are also of Plymetl.

The Locomotive

The diesel-electric locomotive of the Talgo also departs from the normal in both materials and their use.

Low weight per horsepower in the locomotive results largely from using light weight diesels and by using frame members made from high-strength, low alloy steels in a compact design. The light-weight truck-type diesels provide power at a rate of about 13½ lb. per horsepower.

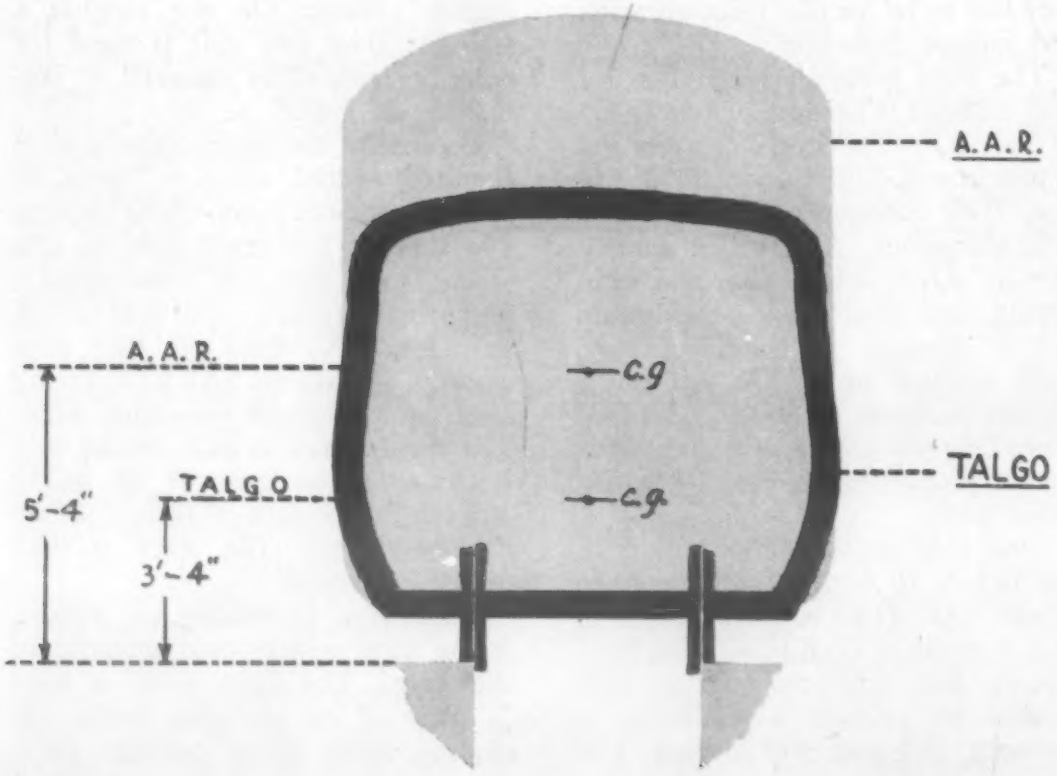
Vibration in the locomotive is virtually eliminated through rubber-in-shear engine mountings. This vibration control plus other means of isolating the power plant such as flexible rubber and metal hose, is expected to add to service life and reduce maintenance costs.

The locomotive cab is of all welded design using girder-type construction. This design is intended to keep deflection to a minimum. Welding was planned and applied so as to reduce distortion and creep. Side panels of the cab are 3/16-in. EVE Plymetl with 24 gage zinc coated steel on both sides. The end sections are ⅛-in. OHS plate. Anti-crash and collision protection is provided in the nose through extensive use of tubular members.

In the operator's compartment a headlining of perforated metal is applied over the entire roof section. Roofing plus an insulated partition reduces the noise level in the cab to a minimum.

Welding is used throughout the locomotive's underframe to join the 12 in. LAHT channels which are spaced 42 in. apart from the center sills. Only one crossbearer is used. The wide spacing permits propulsion engines to be suspended as close to the rails as is possible. Since the undercarriage is of welded construction, the entire structure is stress-relieved.

This sketch shows the lower height and center of gravity of the Talgo as compared with a standard A.A.R. car.



Finishing

No unusual finishes were required for the Talgo, although finishing procedures were developed carefully. The entire exterior of the train is finished with a smudge resistant aluminum paint. This finish first of all resists discoloration and secondly cleans off easily, so that maintenance cleaning of the Talgo is relatively simple.

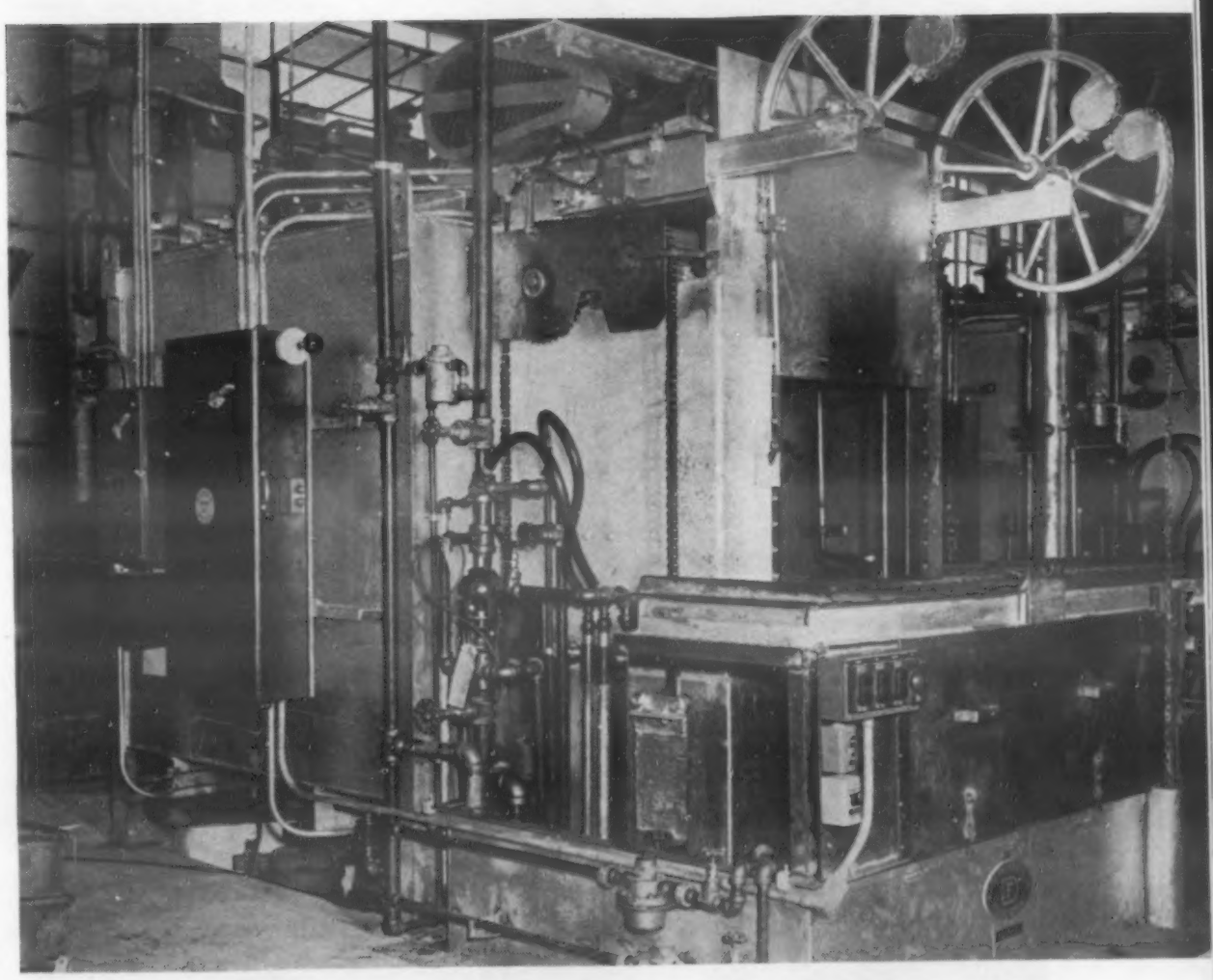
The coaches are finished with standard enamels, made in special colors to carry out the train's decorative scheme. Dado work of the coach interiors is Kalistron a vinyl plastic material. The vinyl used is colorless, and is backed up with paint in the desired color. Thus, scuffing of the surface, wear and other factors will not affect the color unless the material is worn completely through.

Coach floors are covered with sheet rubber which is attached to the Plymetl base by means of a 1/16-in. underlay of plastic material which acts as a filler.

Dry Cyaniding Reduces Costs on Variety of Steel Parts

by F. R. NETHAWAY,
Chief Process Engineer, Oldsmobile Div., General Motors Corp.

In addition to handling batch production at low cost, this set-up permits close control over case concentration and depth, and holds distortion to a minimum.



Gas cyaniding at Olds is performed in furnaces of this type, made by Dow Furnace Co.

• ALTHOUGH OLDSMOBILE specialists in heat treating installed modern facilities for liquid cyaniding and used them by approved methods and with proper care, the operation of this equipment presented several drawbacks:

(1) Operation was disagreeable and potentially dangerous even under optimum conditions. Labor employed did not like working around the furnaces and it proved difficult to keep men on this work. Ventilated cyanide pots with chain falls for dipper or basket transfer, semi-mechanical dumping and conveyorized discharge from oil and water quenches were used but difficulties continued.

(2) Dissociation tended to make it difficult to maintain constant bath composition.

(3) It was difficult to alloy sufficiently the carburized case to permit successful oil quenching of carburized plain carbon steels except in thin sections, hence both oil and water quenches were needed.

(4) Operating costs proved high.

(5) Distortion sufficient to require straightening operations occurred, especially in parts having sections of varying thickness.

(6) Constant aggregation of cyanide waste that required special disposal was a nuisance.

The volume of parts handled was not sufficient to warrant continuous gas cyaniding equipment, hence batch type furnaces had to be used. Until recently, however, heating in batch type furnaces was slow and separate and rather expensive equipment was required to maintain necessary atmospheres. When the Dow batch type gas cyaniding furnace was developed, it overcame these drawbacks and the first unit was installed in the Olds plant. It yielded several advantages besides avoiding the drawbacks of liquid cyaniding and so has been supplemented by the addition of two new furnaces of the same make but

later design.

Benefits secured with the dry gas furnace include:

(1) Improved working conditions.

(2) Lower cost of operation.

(3) Ability to control both case concentration and depth.

(4) Direct quenching in oil only.

(5) Minimum distortion of product with elimination of straightening operations.

(6) Elimination of cyanide waste.

One drawback in gas cyaniding is that when portions of parts must be free of cyaniding, the areas must be plated selectively with copper. There exists also one potential hazard in the form of possible oil fires if loads quenched are excessively dense or if an excessive amount of water is present in the quenching oil. This hazard is avoided by arranging parts so that the load is not too dense and by centrifuging the quench oil to keep water content within safe limits.

Important too is an arrangement whereby the quench oil is made to flow downward through each batch of parts quenched while the tray and box containing the parts are in a position to seal the quenched chute opening, thereby forcing oil to flow through the spaces between the individual parts.

This general arrangement of the furnace causes exceptionally rapid heat transfer below the critical range of the work. For example, in the smaller furnace, 422 lb. net load of pump gear shafts, weighing 0.205 lb. each are brought up to the 1600 F carburizing temperature in 31 min. Similarly, 400 hand brake sectors weighing 362 lb. net, reach the 1550 F carburizing temperature in 27 min.

The U-shape radiant tubes of the furnaces contain in their hot legs, gas generators that convert an air-propane or natural gas mixture (to which ammonia is added for carbonitriding) into the proper atmosphere that is fed into the furnace at the desired rate. These integral generators are simple in operation and save the cost of supplying, operating and maintaining a separate generator.

Typical parts cyanided are illustrated to indicate the temperature and time required to obtain cases 0.002 to 0.032 in. deep in ammonia enriched atmospheres. The time at temperature varies from 5 min. for a 0.002-in. case to 8 hr. for a 0.032-in. case. The latter applies to an oil pump shaft of plain carbon steel alloyed sufficiently with nitrogen during carburizing to yield full hardening by oil quenching. The outer portion of this case is semi-austenitic but this layer is completely removed in finish grinding the shafts.

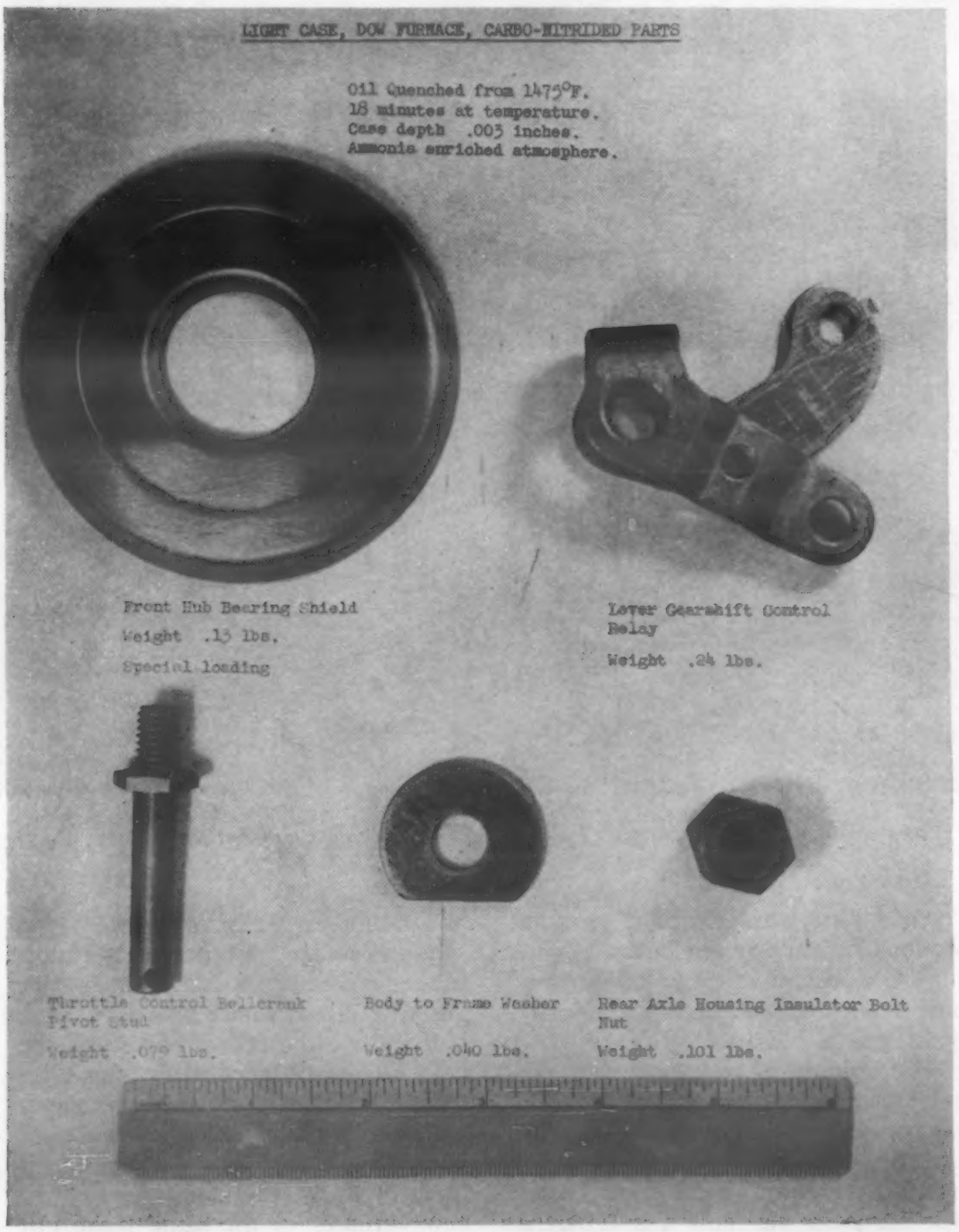
In a hand brake sector and pawl the sector was formerly immersed in liquid cyaniding, enough to cover the teeth and then was oil quenched. Resulting distortion necessitated a restrike operation. With all over gas cyaniding, the part is oil quenched but no restrike is required, as distortion, if any, is slight.

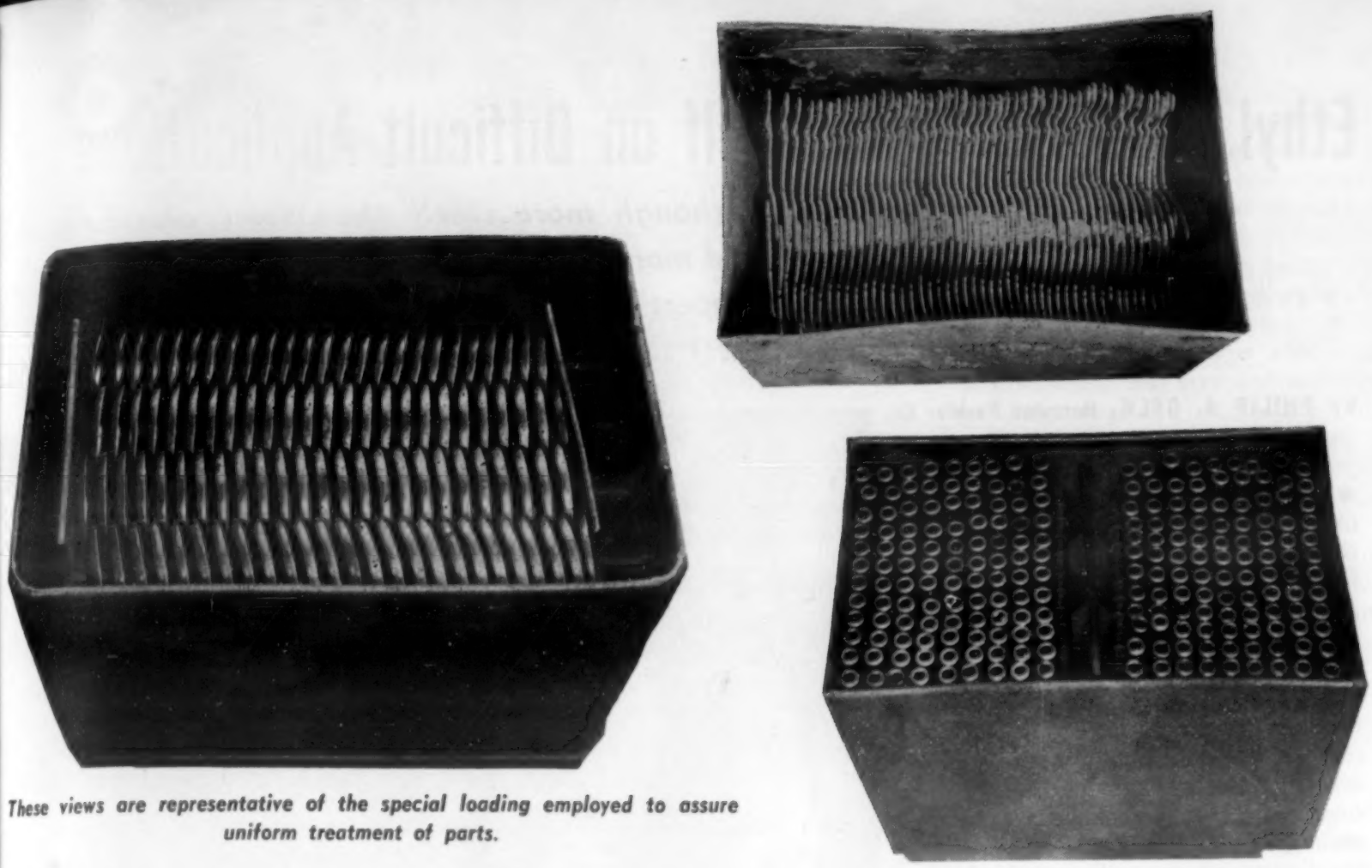
Rocker arm shafts are given a nitrogen-free case of 0.040 in. in a 5½-hr. treatment at 1650 F. This is followed by slow cooling in the chamber above the quench. After subsequent machining, this shaft is step hardened by induction heating and quenching.

When, in the usual procedure, quenching immediately follows cyaniding, the boxes of parts are shifted into the furnace vestibule after lifting the door between the vestibule and the heating chamber. Screw conveyors on the hearth in the later model of furnace facilitate this transfer and the boxes come to rest on an inner elevator that serves the vestibule. The outer door is then closed and the elevator lowers the load, still in boxes, into the quench after the oil is set in rapid motion by a propeller provided for this purpose in the lower part of the quench tank.

As the box and elevator close the inlet opening to the propeller except for spaces between the parts to be quenched, the oil is drawn positively through these spaces (through which gas circulated during heating and carburizing) and quenching is both rapid and uniform. In the case of small parts, such as nuts, where no special loading is done to maintain uniform

Parts such as these are given a light case, as explained on the illustration.





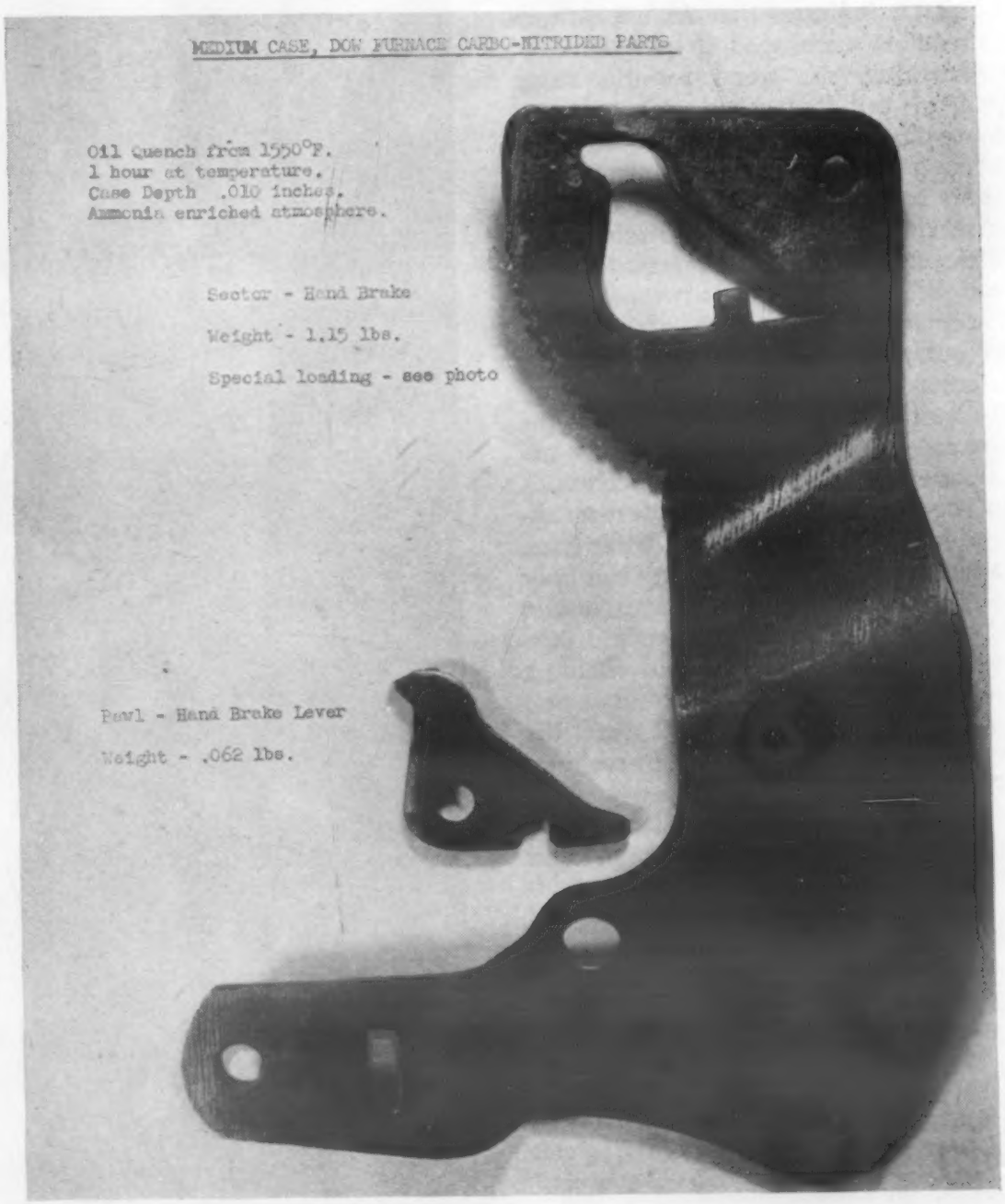
These views are representative of the special loading employed to assure uniform treatment of parts.

space between parts, the depth of load has to be carefully controlled, so as not to unduly restrict the flow of gas or of quench oil.

After parts are loaded in boxes, they are rolled along a conveyor and then, when the furnace is empty, are pushed onto an outer elevator and thence across the inner elevator onto the screw conveyors set in the hearth. These screws are driven slowly in one direction for loading the furnace and are reversed when unloading. After loading the furnace, the operator closes both doors and sets controls that cause the furnace to run through its cycle automatically. Thus, attendance is required only during loading, unloading and quenching, or about 10% of the average cycle time. After the first pair has been in the quench a short time, the vestibule elevator is moved up and the boxes are rolled onto the outer elevator on which they can be lowered into the quench again if not cool enough to be dumped. When the vestibule elevator is unloaded, it is ready to handle the second pair of boxes through the quench. The newer furnaces, besides having screw conveyors on the hearth, are larger and so can handle more parts per hour. An improved fan and large generators are included.

Mention has already been made of lowered costs achieved in gas as opposed to liquid cyaniding. The cost for liquid cyaniding ran more than 80% higher than for gas cyaniding. There is therefore a substantial cost advantage in addition to the other benefits mentioned above.

Below: These parts, both for a hand brake, are given a heavy case, as described.


MEDIUM CASE, DOW FURNACE CARBO-NITRIDED PARTS
Oil Quench from 1550°F.
1 hour at temperature.
Case Depth .010 inches.
Ammonia enriched atmosphere.
Sector - Hand Brake
Weight - 1.15 lbs.
Special loading - see photo
Pawl - Hand Brake Lever
Weight - .062 lbs.

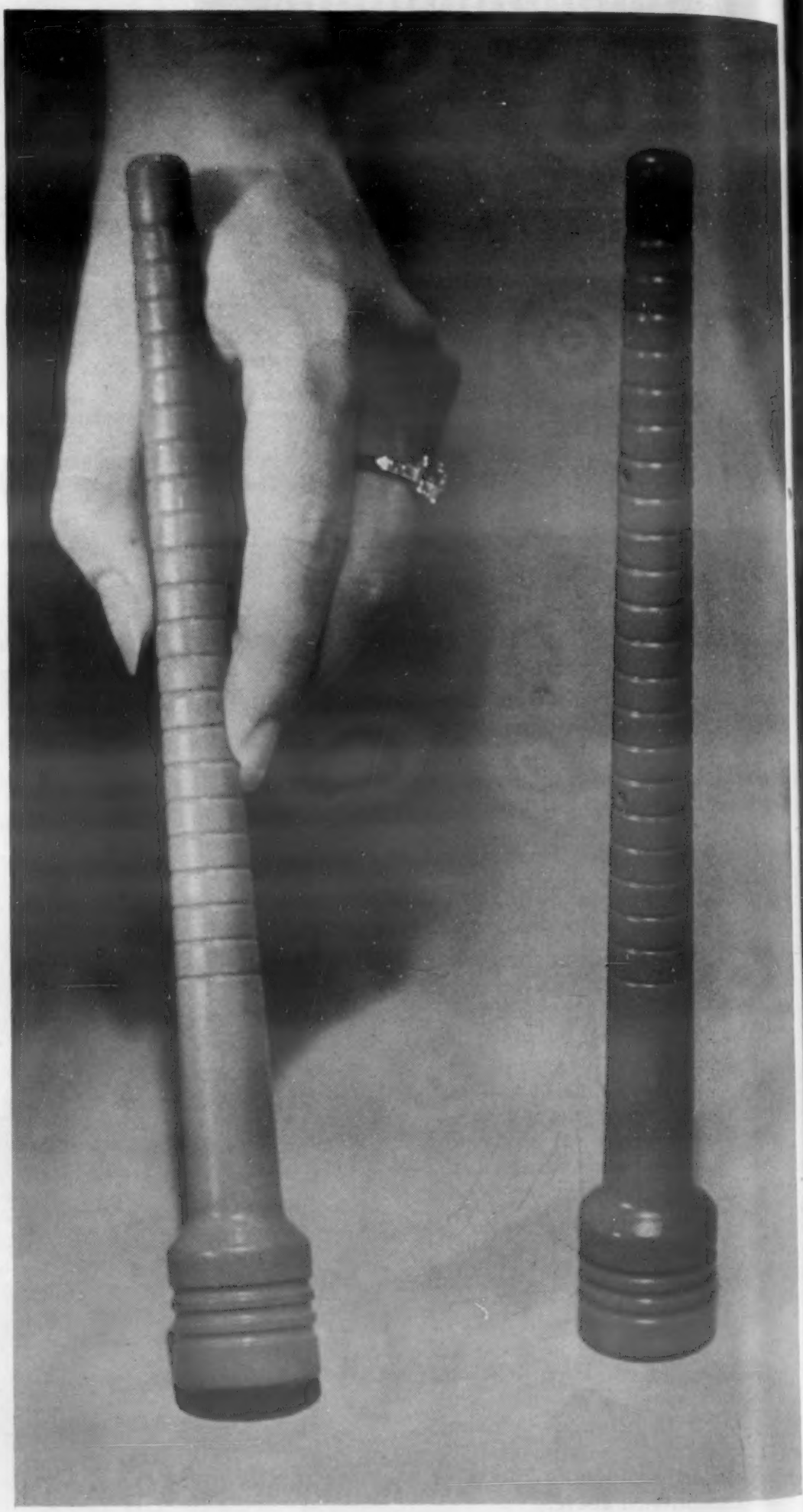
Ethyl Cellulose Proves Self on Difficult Applications

Although more costly than some plastics and more difficult to mold than others, the properties of ethyl cellulose make it the most satisfactory material for many tasks.

by PHILIP A. BELK, Hercules Powder Co.

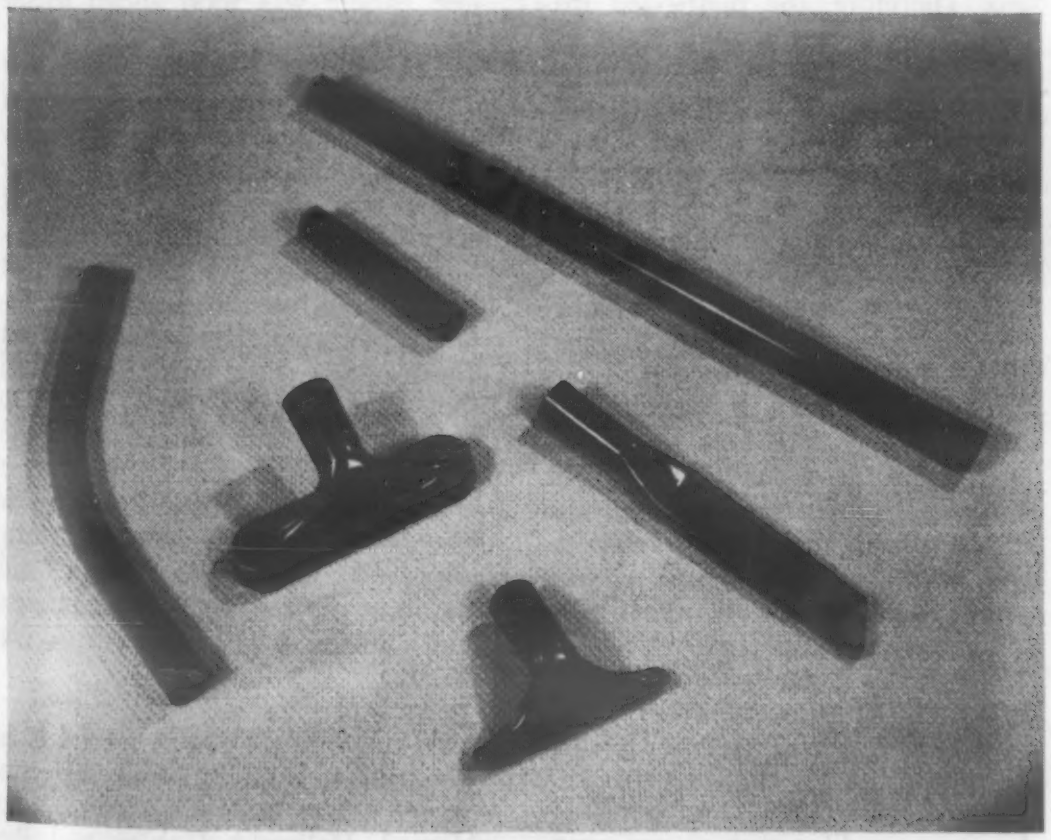
● The ability of ethyl cellulose to meet the rigid material specifications for such military applications as the famed VT proximity fuse was responsible for its first widespread use in molded form, and its subsequent recognition as a thermoplastic material providing highly satisfactory performance under severe conditions of temperature and humidity. Communication set housings, flashlight cases, lanterns, and gas masks were among the other uses where its toughness and versatility enabled it to perform well in wartime applications. A check of the hundreds of current applications of this rugged plastic indicates that its use pattern remains unchanged in peacetime. If anything, the trend towards using ethyl cellulose when the going is roughest has become more pronounced, so that today manufacturers and molders alike look to it for service in jobs where no other plastic can fulfill the use requirements.

Ethyl cellulose has won this acceptance in the face of two discouraging drawbacks: high material costs and a number of difficulties encountered in molding. Prior to the war, few molders had had any experience at all with ethyl cellulose. The formulations which were available had a limited range of far from satisfactory colors. Moldings had poor gloss, shrinkage was serious, cycles were long, and the tendency of the ethyl cellulose material in molding powder form to absorb moisture posed many problems that taxed the ingenuity of the average molding plant. The tremendous urgency of the VT fuse program was responsible more than anything else for the rapid development of a satisfactory molding technique, which in a matter of



Among the newer types of textile bobbins made of ethyl cellulose is this automatic loom bobbin molded from a special formulation. (Unless otherwise credited, photos are furnished by the Hercules Powder Co.)

One of the first products to be molded of ethyl cellulose was this two-piece "Walkie Talkie" case made early in World War II. After prolonged exposure, halves fit snugly together without evidence of warpage, as this recent photograph shows.



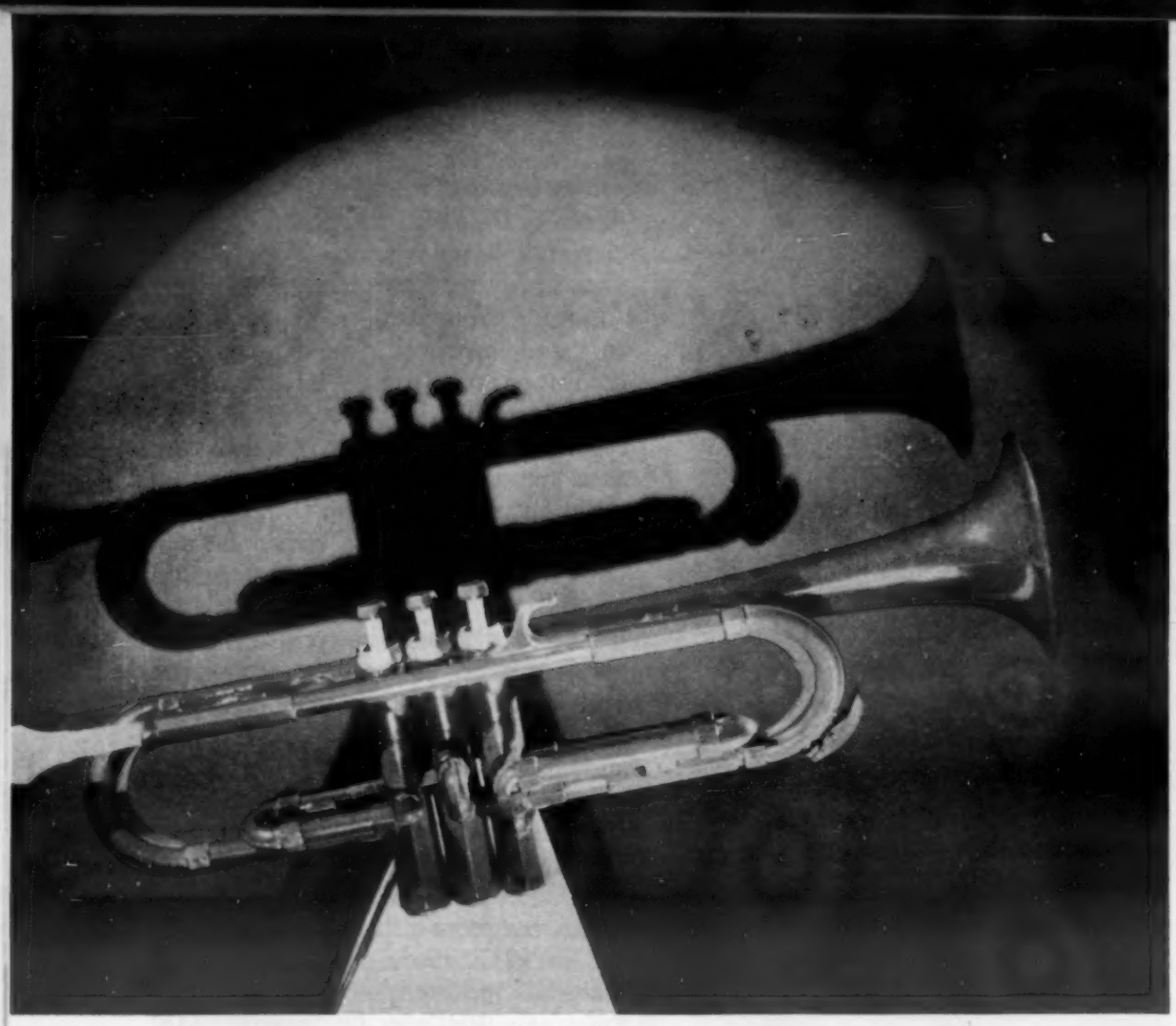
The combined weight of these vacuum cleaner tools molded of gray ethyl cellulose for the Kirby Vacuum is 15 oz. (Courtesy Dow Chemical Co.)

only months enabled molders to effect drastic cuts in production cycles. Die designs which made proper allowance for its mold shrinkage (ranging from 0.002 to 0.007 in. per in.) and improved drying techniques combined to provide a satisfactory overall production process for ethyl cellulose and won for it a position as a standard and accepted injection molding material.

Those who use it today find it hard to realize that in a short period of less than 15 years this new plastic has moved from the position of a comparatively unknown and little understood material to one with recognized commercial possibilities and an established reputation as the toughest and most versatile of the cellulosic family. Ethyl cellulose was first made in the United States by the Hercules Powder Co. in 1935, and subsequently by Dow Chemical Co. in 1937. Early data on this new material pointed to its extreme toughness, low specific gravity (1.09 to 1.14), ultraviolet resistance, low moisture absorption, its ability to mix with amorphous waxes, and its affinity for various plasticizers. In the beginning, no effort was made to offer this new material as a competitor for existing resins. Rather, its use was directed to tasks where other materials had failed, or their known limitations indicated that they were unqualified to serve. In the short period of its history prior to the war, it was tried in a broad range of applications—as a stiffener for textiles; wire coating; a binder for loose tobacco at the end of cigarettes; in lacquer; and as transparent sheeting for packaging. But until the war gave it its big break, ethyl cellulose saw little use as an injection molding material.

Toughness and dimensional stability along with its dielectric properties were responsible for the selection of ethyl cellulose as a molding material for the nose of the VT fuse. Many of the techniques which developed in the course of the fuse program have now become the standard and accepted practice in the molding of ethyl cellulose. It was found that high temperatures (460 to 550 F) and low pressures provided a satisfactory molding cycle. Infrared drying of molding powder solved the moisture collection problem.

The great assets of ethyl cellulose are its high impact strength which is retained at temperatures as low as —40 F; its fine dimensional stability; and its flexibility over long periods



This trumpet is fabricated entirely of ethyl cellulose. Valves are machined to tolerances of less than 0.0005 in. The instrument is said to have high tonal quality. A special formulation of ethyl cellulose was developed by Dow Chemical for the trumpet produced by the Trophy Products Co.

under extreme atmospheric conditions. Then too, it has a low softening point and a high melting point, yielding fast economical molding cycles. Its specific gravity of about 1.12 makes it among the lightest of all the thermoplastics; it is stable to alkalies and to salt solutions and has excellent electrical properties. As against these assets, its high material cost, a somewhat limited range of colors, and the critical molding conditions which its use entails have prompted many a molder to pass it by without rendering an equitable evaluation. Faced, however, with increasing demands for a plastic material that can serve where severe exposures are indicated, many manufacturers have returned to re-evaluate ethyl cellulose when other thermoplastics have been tested and found wanting. As a result, it has been tried and has won itself an important place, particularly in the industrial field.

Ethyl cellulose differs chemically from other cellulosic materials in that it is an ether and not an ester. It is produced by the action of a strong alkali such as sodium hydroxide on the same type of cellulose that is used in the manufacture of other cellulosic materials. This reaction produces alkali cellulose which is then treated with an ethylating agent such as ethyl chloride or sulfate to produce the ethyl cellulose which when washed and purified becomes the white granular flake which is the base for ethyl cellulose molding compounds. An important asset of ethyl cellulose is that it can be compounded with extremely low amounts of plasticizers, and that these plasticizers can be introduced by the aid of heat and mechanical working alone with no intermediate colloiding step. Therefore, the plasticized material has all the toughness of its cellulose base while retaining through its service life all its small amount of modifier. The low plasticizer content of ethyl cellulose formulations contributes in part to their exceptional dimensional stability.

The same physical characteristics which were responsible for ethyl cellulose's widespread use in wartime have enabled it to establish a firm foothold in the mechanic's tool industry, where it is now finding increasing use as a handling material. With its high impact strength and form retention over a broad temperature range, it has supplanted conventional hardwoods and other plastics in screw driver and chisel handles, hammer faces, saw handles, and parts for bit braces and drills. Fabricators have found that with only slight changes in techniques they can cut, turn, drill, tap, and polish it almost as readily as they can nitrocellulose—a material which has long been recognized for its extreme ease of workability. Today a number of types of mechanic's tool handles are fabricated with extruded ethyl cellulose rod, while others are molded, often in designs incorporating metal inserts. Like all the cellulosics, ethyl cellulose combines well with metal, and when inserts are used, provides an excellent assembly that will not loosen with aging.

Faced with a shortage of good quality hardwood, one New England tool manufacturer turned to ethyl cellulose about two years ago for a handling material for its bit braces. The Peck, Stow & Wilcox Co. conducted extensive tests on various plastics before molds were built. Ethyl cellulose proved far superior to all other materials which were examined. Once convinced that it would meet every structural requirement, Pexto engineers redesigned their bit brace to make use of ethyl cellulose. Using a center piece molded in two sections and a solid molded headpiece, it was possible to eliminate many assembly operations and substantially reduce scrapped parts. Although the plastic parts as compared to those made of wood were initially higher in cost, production savings enabled the manufacturer to market the new braces at competitive prices. The success enjoyed by this new plastic-handled tool subsequently encouraged Pexto to shift to ethyl cellulose in another application, and as a result, a colorful and attractive try-square with a molded ethyl cellulose handle was soon added to the line.

Until recently, one of the great drawbacks to the increased use of fabricated ethyl cellulose for screw driver and chisel handles and hammer faces, was the limited degree of color and clarity in the formulations available. The eye appeal of less durable but more attractive materials put ethyl cellulose at a distinct disadvantage at the point of sale, and tool manufacturers were forced to consider less suitable materials to protect their markets. During recent months, however, new formulations have been developed with greatly improved color and clarity which still maintain the strength and toughness which no other cellulosic plastic can match.

Manufacturers have also turned to ethyl cellulose for use in special tools where no material had hitherto proved able to serve. The Airco Manual Heliweld Holder and the Roberton Electric Hedgeclipper are good examples of this application.

Air Reduction's new manual heliweld holder is designed to provide a lightweight tool for heavy-duty production service. Use of ethyl cellulose in the tool holder provided extreme lightweight and the exceptional strength and rugged toughness needed to withstand exposure to harsh service conditions. Good moisture resistance was required, too, since a built-in water system extending almost to the point where the holder grips the electrode, continuously exposes the molded part to moisture whenever the tool is in operation. An ethyl cellulose molding in this unit also facilitated assembly, cutting manufacturing costs.

In the redesign of the Roberton electric hedgeclipper to provide a more attractive and functionally improved product, ethyl cellulose played an important part. It was selected as a material for the handle, replacing the molded rubber part used in the old style model. To provide improved balance and ease in operation, the handle in the new model was located between the motor and shears, with motion transmitted through a die-cast rod, covered with the two-piece ethyl cellulose handle. Use of ethyl cellulose provided a tough, virtually unbreakable handle that could withstand severe exposures. Molded-in ribs made the handle easy to grip. Its rich, warm color contrasted well with the grey overall finish of the rest of the unit, with the wiped-in white lettering providing good identification of the manufacturers trade name.

Another new ethyl cellulose application which ties in well with one of the wartime uses is the housing for the ringer case of the Wheeler self-powered telephone. In this instance, a material with good resistance to corrosion, extreme variations in temperature and humidity, shock and vibration, was required. In many respects, the specifications were similar to those for the communication set housings used by the military. Standard handsets compression molded with a thermosetting material were in the first models of the new Wheeler phone, but the exceptional performance of the ethyl cellulose in the ringer case has already prompted the manufacturer to consider an injection molded handset of ethyl cellulose for future models in this unit. Handsets and telephone bases have also been molded with ethyl cellulose by Western Electric and are now undergoing extensive field tests.

In housing applications, the use of ethyl cellulose has run the gamut, ranging from radio cabinets to ice buckets, and including vacuum cleaner fittings, hearing aid cases, broom caps, and clock cases. If further proof of its versatility were needed, consider this broadranging list of uses: toys, toilet seats, bowling pins, golf club heads, crib and bus rails, flashlights, drafting tools, and refrigerator frames. Wherever rich color, exceptional toughness, and extreme lightweight are required, it offers a material that will match any other and out-perform most.

What are the new horizons for ethyl cellulose? One important new potential lies in the vast market for a bobbin material for the textile industry. In a fast-changing world, where almost every machine and component we use has undergone a rapid succession of changes during the past fifty years, textile bobbins until recently were substantially no different than they were a century ago. Still made of wood, and in almost exactly the same shapes as the ones used on the first spinning and weaving machines, they served well but had a limited life (5 years or less), and many other shortcomings. Shortly after the war, the first successful braiding bobbin to be molded with a thermoplastic material was placed on the market. Already these new bobbins have proved themselves in service, and in many factories the new plastic bobbins—molded with a tough formulation of ethyl cellulose especially developed for the job—are gradually replacing their wooden predecessors. These new bobbins can withstand an unbelievable amount of abuse. They are splinterproof and tough, and able to resist the tremendous compression of layer upon layer of tightly wound nylon yarn. Their performance has encouraged other branches of the textile industry to consider ethyl cellulose for a variety of similar bobbin applications. In many cases, molds have already been built and samples are under test.

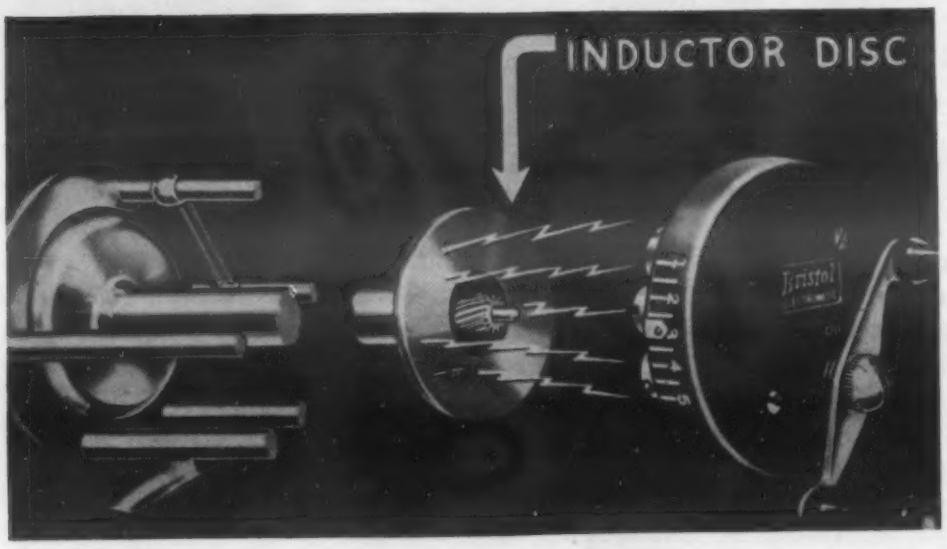
Those closest to the development of ethyl cellulose look for its broadened use in many fields where specifications are not nearly so critical—where new formulations might be developed that would adapt themselves to lower mold temperatures and pressures—formulations that would provide for easier molding, improved color and surface finish without sacrificing the degree of impact strength and dimensional stability required by the job at hand.

Properties of Ethyl Cellulose

Compression molding temperature, F	250-390
Compression molding pressure, psi	500-5000
Injection molding temperature, F	350-500
Injection molding pressure, psi	8000-32000
Mold shrinkage, in. per in.	0.002-0.009
Specific gravity	1.09-1.17
Tensile strength, psi	2000-8000
Elongation, %	5-15
Modulus of elasticity in tension, psi x 10^5	0.5-4.0
Compressive strength, psi	4000-15000
Flexural strength, psi	5000-10000
Impact strength, ft.-lb. per in. of notch (½ by ½ in. notched bar, Izod test)	2.0-8.0
Hardness, Rockwell	R70-R110
Thermal conductivity, 10^{-4} cal. per sec. per sq. cm. per 1 C per cm.	3.8-7
Resistance to heat, F (continuous)	115-185
Heat distortion temperature, F	115-190
Dielectric strength, short-time, ⅛-in. thickness, volts per mil	350-500
Water absorption, 24 hr., ⅛-in. thickness, %	0.8-1.8
Burning rate	Slow

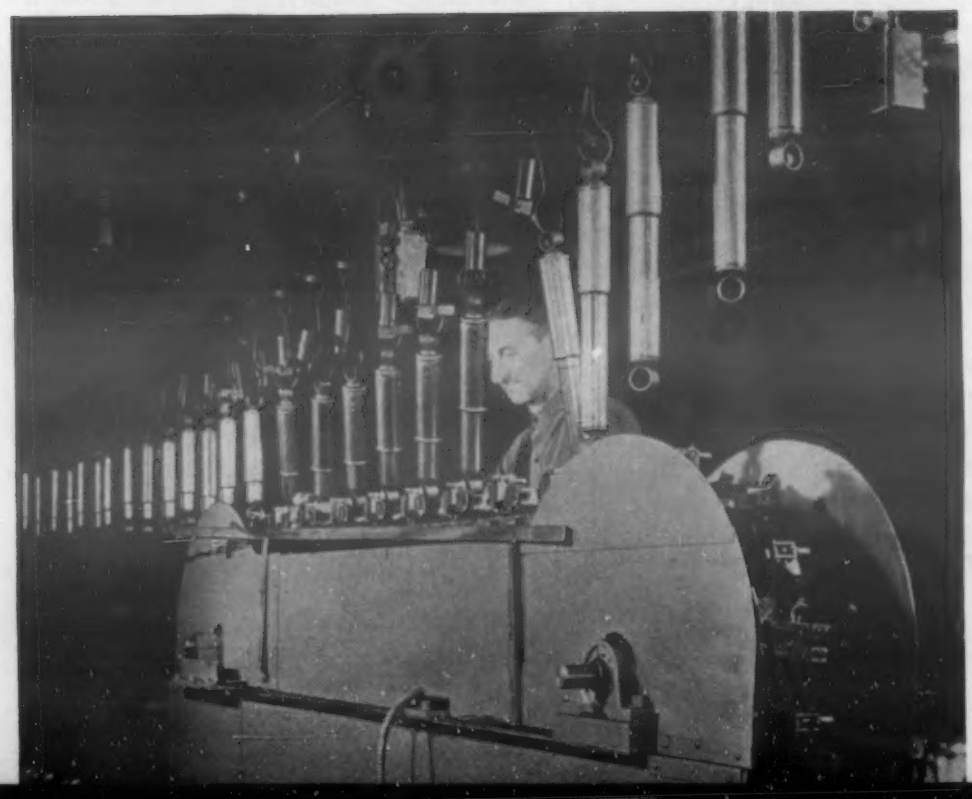
Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .



BIMETALLIC FISHING REEL BRAKE

Providing an automatic "drag" or brake on fishing reels produced by the Horton Manufacturing Co. and the Ocean City Manufacturing Co., this bimetallic inductor washer disk eliminates back lash in casting. Sheets of 0.20-in. copper and 0.004-in. steel are bonded metallically by the Laminated Shim Co., and washers stamped out to a tolerance of plus or minus 0.001 in. on the diameters. Concentricity is within 0.001 in. The smooth casting action of the reels results from the use of three G.E. Sintered Alnico permanent magnets mounted on a nonmagnetic plate having an adjustable air gap. The bimetallic disk is mounted on the end of the spool and cuts the lines of force of the permanent magnets. The eddy currents induced by rotation set up electromagnetic poles in the disk, which repel the permanent magnet poles and produce a drag on the speed of the spool. Since the strength of the electromagnetic poles depends on the speed of rotation of the spool, the automatic braking effect is always applied in just the right amount.



STEEL TUBE CYLINDERS

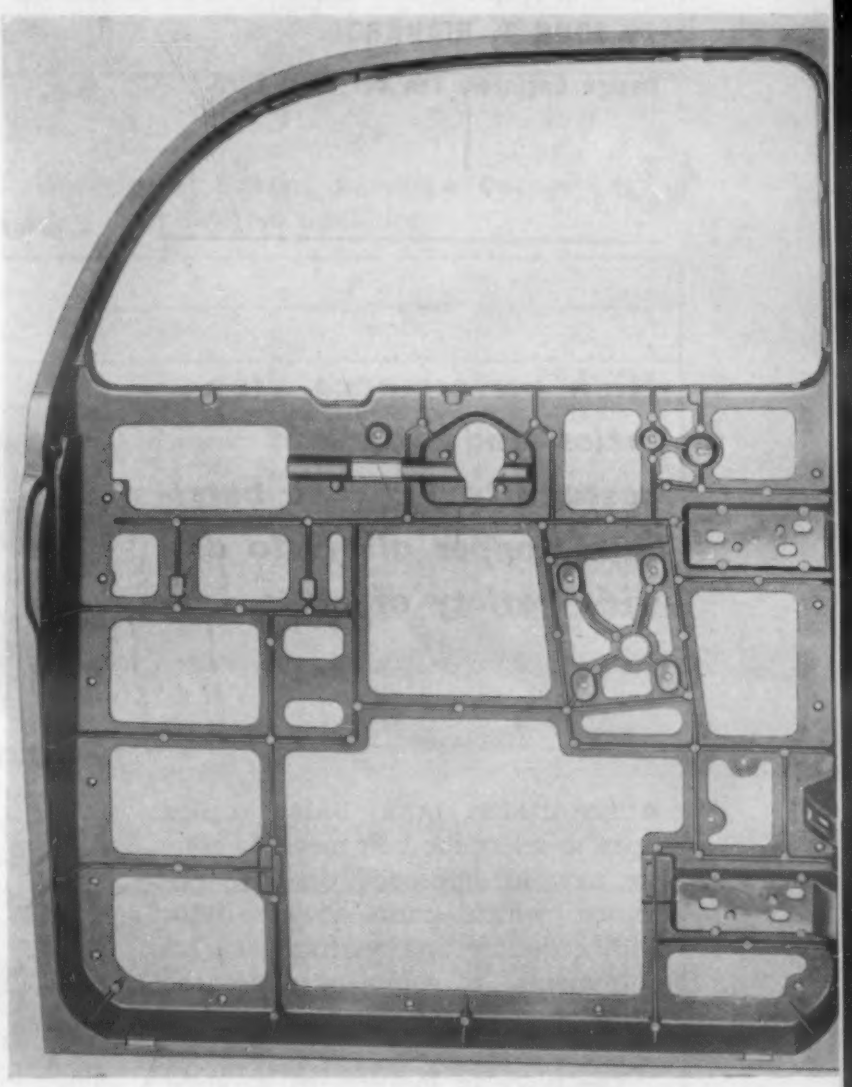
By eliminating the use of expensive drawn-over-mandrel tubing, the Houdaille-Hershey Corp. reduces costs in the manufacturing of airplane-type shock absorbers for automotive use. Electricweld tubing of resulfurized free-machining open hearth steel, a product of the Jones & Laughlin Steel Corp., is utilized for the shock cylinders, the interior surface of this tubing being broached to the close tolerances required for efficient shock absorber operation. Cylinders made in this way are used in different sizes of units, with collapsed lengths varying from 8 to 15 in. During production, each of these units is tested for leaks under 90 to 100 lb. of air pressure.

WOODEN PIPE LINE

Measuring 12 ft. in dia., and constructed of 4- by 6-in. redwood timbers milled to a curvature on both inside and outside surfaces, this pipe line will be used to divert water from the Umpqua River to a hydro-electric plant of the California Oregon Power Co. To prevent leakage, the pipe staves have tongue and groove joints, and malleable iron clamps are used to fasten the ends of the staves. Under operating pressures, the pipe will be held together with ¾-in. upset thread hoops. Malleable iron pipe shoes connect the sections and tighten each section in place. Steel bands are placed approximately 5 in. center to center along the entire 1645 lineal ft. of pipe length. The completed pipe line, constructed by the Santa Fe Tank & Tower Co., will be supported by reinforced concrete cradles on 8- to 10-ft. centers, depending on curvature at any given point.

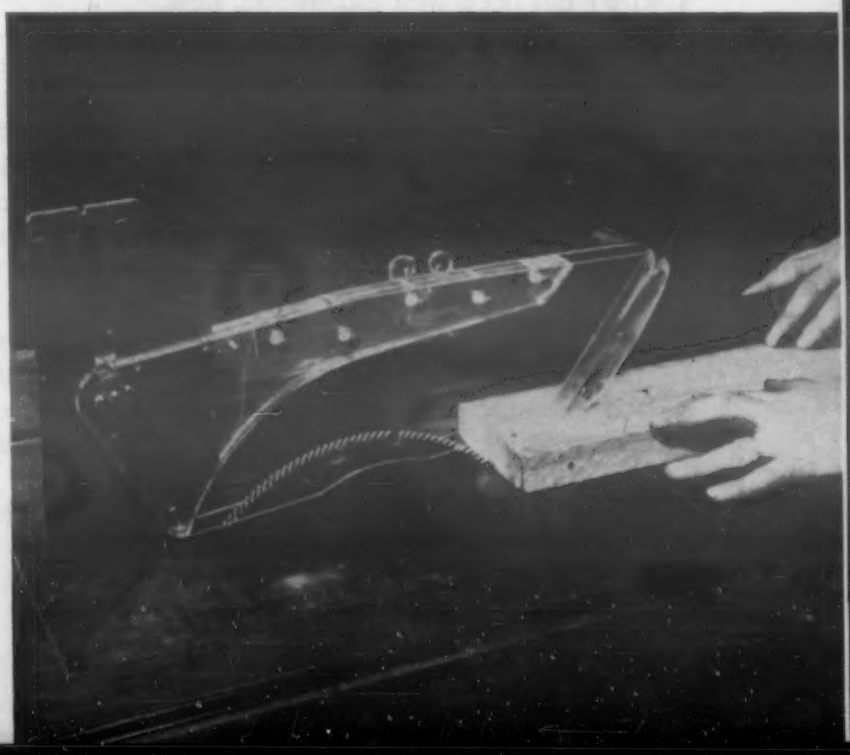
DIE CAST ALUMINUM AUTOMOBILE DOOR

Reportedly the largest in area ever produced, this die casting of special aluminum alloy forms the structural base to which the sheet steel outer panel is attached. The door, designed and produced by the Doehler-Jarvis Corp. in collaboration with the Kaiser-Frazer Corp., measures 43 in. long by 33 in. wide and weighs slightly more than 12 lb. when trimmed. Die casting permits wide use of the reinforcing ribs needed for stiffness and rigidity in parts of this sort and which are difficult to obtain economically in standard sheet metal practice. In addition, the die cast frames eliminate the variations and subsequent "handfitting" operations customarily encountered with sheet metal assemblies. This results in lower production costs and higher assembly rates.



TRANSPARENT ACRYLIC SAW GUARD

Providing an unimpeded view of the saw blade and work, this transparent Plexiglas guard is produced by the Laminated Sheet Products Corp. for circular saws 8 to 20 in. in dia. A pin arrangement allows the guard to be held in a vertical position for adjustment or changing of blades. The light weight of the shatter-proof plastic and the free pivoting of the mounting make the guard self-adjusting to work of any height. The guard is designed for spreader mounting, but is available without a spreader for those who prefer to adapt the mounting to their own requirements. In such instances, mounting can be made from above or from the side.

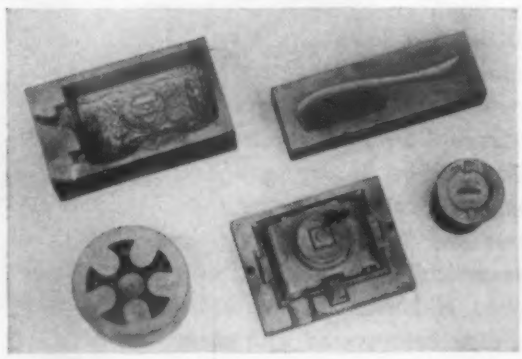


Designing with Beryllium Copper Casting Alloys

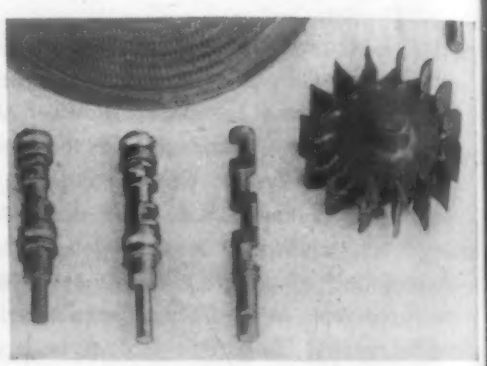
by JOHN T. RICHARDS,
Design Engineer, The Beryllium Corp.

A group of typical beryllium copper sand castings, including electrical and mechanical parts, safety tools and plastic molds.

High performance properties and excellent castability fit cast beryllium copper alloys to a wide variety of parts.



Pressure-cast plastic molds of beryllium copper "as-cast and liquid honed." No further machining required.



Miscellaneous beryllium copper parts cast by plaster-mold process. Hardness values can be increased from Rockwell B60 to C44 through heat treating.

● ENGINEERS ARE DAILY called upon to select the best metal or alloy for new or improved designs. The choice, which must be consistent with economy and performance requirements, is complicated by the wide range of available materials and forms.

The place in industry of wrought beryllium copper (strip, rod and wire) has been well established. Less, however, has been reported concerning cast beryllium copper, although age-hardened castings deliver the same useful properties as obtained in wrought forms. This means that cast parts, depending upon the alloy selected, offer tensile strengths up to 190,000 psi. or hardnesses to 450 Brinell, or electrical conductivities to 50% that of pure copper.

In addition to high strength and good conductivity, the following characteristics of beryllium copper may be of interest to materials engineers:

1. Non-magnetic.
2. Good resistance to wear and corrosion.
3. Superior elevated-temperature properties as compared to other copper-base alloys.
4. Retention of ductility in sub-zero atmospheres preventing loss of impact strength or low-temperature embrittlement.
5. Good fluidity in the molten state resulting in maximum detail in "as-cast" parts with minimum machining.
6. Relatively low pouring temperature facilitating foundry handling.

There are now produced several beryllium copper alloys—each presenting a different combination of desirable properties. Table I gives nominal compositions for three casting alloys.

The alloys containing 2.0 and 2.7% beryllium may be called "high-strength;" the 0.6% material, "high-conductivity." High-strength alloys generally find use where strength and hardness are of greater importance than electrical or thermal conductivity. The standard 2% alloy (No. 20) is the most universally employed casting material, while the others are of more limited application.

Physical properties of beryllium copper casting alloys are listed in Table II. Table III affords a comparison among several casting alloys.

Selecting Casting Method

Beryllium copper parts are regu-

larly produced by sand, permanent mold, pressure, plaster and investment casting methods. The following discussion covers the advantages and limitations of each method:

Sand—Sand casting frequently offers the lowest cost answer for simple shapes requiring a minimum number of finishing operations and may provide the only feasible method of producing large parts. Sand castings are limited in size only by available melting and handling facilities.

Beryllium copper sand castings find wide use in electrical and mechanical parts. The high-conductivity alloy (No. 10) is especially suited for current-carrying spring components in switches, circuit breakers, and switchgear. In the welding field—welding jaws, resistance welding dies and electrode holders are frequently sand cast, particularly where size and shape requirements prevent economic use of wrought materials. High thermal conductivity, coupled with good resistance to wear and moderately elevated temperatures, suggest successful application in certain types of friction members.

High-strength sand castings (Nos. 20 and 275) serve as bushings, cams, pump parts, bearings, gears, flash welding dies, valve parts, and similar applications. For marine propellers, the excellent corrosion resistance and high strength permits thinner sections with added resiliency. Beryllium copper molds for plastics are frequently sand cast where few cavities are required. Its high resistance to spark emission as compared to ferrous materials makes beryllium copper suitable for safety tools in locations made hazardous by threat of fire or explosion. In addition to non-sparking tendencies, these tools are non-magnetic and resist corrosion.

Sand casting practice for beryllium copper is similar to that employed with other high-copper alloys. Electric, coke, oil or gas furnaces can be used; however, some care must be exercised to prevent excessive gas absorption. Fluxes or charcoal covers are generally not necessary for small heats. Although pouring temperatures vary with section thickness and casting size, high-strength alloys are usually poured in the range 1950 to 2050 F, while the high-conductivity material is poured around 2200 F. Aluminum bronze gating techniques apply.

Permanent Mold—Permanent mold casting makes possible high

Table I—Nominal Composition of Beryllium Copper Casting Alloys

	Alloy		
	20	275	10
Beryllium	2.00-2.25	2.60-2.85	0.55-0.70
Cobalt	0.35-0.60	0.35-0.65	2.35-2.60
Copper	Balance	Balance	Balance

Table II—Typical Physical Properties of Several Beryllium Copper Casting Alloys in Fully Heat Treated Condition

	Alloy		
	20	275	10
Specific Gravity	8.09	8.09	8.61
Density (Lb. per Cu. In.)	0.292	0.292	0.311
Magnetic Properties	non-magnetic	non-magnetic	non-magnetic
Melting Range	1585-1750	1585-1750	1825-1950
Modulus in Tension, Psi.	19,000,000	19,000,000	18,000,000
Average Coefficient of Linear Exp.			
(Per Deg. F)	0.0000095	0.0000093	0.0000098
(Per Deg. C)	0.0000170	0.0000166	0.0000177
Thermal Conductivity			
(Btu./Sq. Ft./Ft./Hr./Deg. F)	67-75	59-69	133-150
(Cal./Sq. Cm./Cm./Sec./Deg. C)	0.27-0.31	0.24-0.28	0.54-0.61
Shrinkage (In. per Ft.)	3/16	3/16	3/16

Table III—Several Casting Alloys Compared

Alloy	Composition, %	Condition	Tensile Strength, Psi.	Yield Strength (0.2% Offset) Psi.	Elongation in 2 In., %	Hardness		Electrical Conductivity % IACS	Thermal Conductivity CGS
						Rockwell	Brinell (3000 Kg.)		
Beryllium Copper 20	2.0 Be, 0.5 Co, bal. Cu	Quenched 1450 F, aged 600 F	160,000	135,000	2	C40	372	25	0.29
Beryllium Copper 275	2.7 Be, 0.5 Co, bal. Cu	Quenched 1450 F, aged 600 F	175,000	150,000	1	C43	407	22	0.26
Beryllium Copper 10	0.6 Be, 2.6 Co, bal. Cu	Quenched 1700 F, aged 900 F	95,000	80,000	8	C22	240	45	0.54
Aluminum Bronze	10.75 Al, 4 Fe, bal. Cu	Quenched 1625 F, aged 1000 F	105,000	75,000	6	B98	225	13	0.18
Manganese Bronze	3.5 Mn, 5.5 Al, 3 Fe, 26 Zn, bal. Cu	As cast	115,000	85,000	15	B95	210	12	0.17
Tin Bronze	8 Sn, 1 Pb, 4 Zn, bal. Cu	As cast	40,000	20,000	30	B40	—	12	0.17
S Monel	30 Cu, 4 Si, 2 Fe, bal. Ni	Quenched 1600 F, aged 1100 F	125,000	95,000	2	C36	330	3	0.06
Medium Carbon Steel	0.3 C, 0.8 Mn, 0.4 Si, bal. Fe	Quenched 1650 F, tempered 1100 F	95,000	68,000	24	B92	192	11	0.17
Stainless Steel	18 Cr, 8 Ni, 0.07 C, bal. Fe	Quenched 1900 F	85,000	40,000	40	B85	165	2	0.04

rates of production over long runs, where the number of units is great enough to offset the initial mold cost. In addition to production economies, permanent molds insure uniformity and minimize finishing operations through faithful reproduction of surface detail.

Moderate strength and hardness are obtainable in permanent mold castings heat-treated from the "as-cast" condition, since the relatively high heat transfer rate through the mold serves as a partial quench. For maximum properties, castings should be solution annealed prior to age-hardening.

Pressure—The unique combination of properties available in beryllium copper pressure castings suggests many applications. Parts, which are cast under pressure applied by a hydraulic press, have an unusually dense structure together with excellent surface finish, which retains the detail of the master hob. Finishing operations are limited to liquid honing. Through age-hardening, pressure castings obtain a high degree of strength and hardness coupled with good conductivity.

Beryllium copper molds have effected important cost-savings in the plastics industry and are extensively employed in the injection molding of many industrial and novelty parts. Sand cast molds are used for large cavities or forces exceeding 50 lb. or where few castings are required. Pressure cast molds, however, prove more economical in many applications through fewer finishing operations.

Advantages of pressure cast beryllium copper molds follow:

1. Low initial cost through the elimination of expensive machining necessary in steel cavities where hobbing is not practical.
2. Since cavities are produced from master hobs, multiple cavities of exact likeness are readily produced at low cost.
3. Sound castings, free from porosity, mean good properties as measured by high compressive strength and hardness.
4. A thermal conductivity 2½ times that of steel gives substantially increased production rates.
5. Cavities can be chromium plated when necessary to prevent corrosion by certain plastics.
6. Raised sections including lettering can be pressure cast with beryllium copper, whereas steel cavities require machined inserts.
7. "As-cast" tolerances for pressure castings can be held to plus or minus 0.004 in. per in.

These same advantages are also of significance to the die caster, since they offer reduced tooling costs in the preparation of short-run dies.

Best results have been obtained through the use of the 2.7% beryllium-content alloy (No. 275) as a mold material. Molten beryllium copper at 2000 F is poured into a steel cavity, then pressure is applied before the metal freezes. Hydraulic presses of 20 to 200 tons capacity will supply required pressures ranging from 2000 to 10,000 psi., depending upon size and shape of hob. After removal from the press, castings are solution annealed 1 to 3 hr. (depending upon section thickness) at 1350 F, followed by an immediate water or oil quench. Cavities are then liquid honed prior to the hardening heat-treatment of 3 hr. at 600 F.

Plaster-Mold—Plaster-mold castings generally range from small to medium in size and are superior in surface finish to sand cast parts. The good castability of beryllium copper aids in attaining dimensional accuracy. Tolerances of the order of plus or minus 0.005 in. per in. can be held over small sections. Cast parts generally require little machining; however, where necessary for critical applications, some allowance should be made to permit a light, finishing cut. Beryllium copper parts cast by the plaster-mold process offer sharp detail, smooth surfaces, good dimensional control, and uniformity over long runs.

In plaster-mold work, polished metal patterns are required, since dimensional control is determined by pattern accuracy. The first step in the process is the introduction of fluid plaster around the patterns, which are removed from the mold when plaster solidifies. Molds and cores are then baked to drive off moisture, so that little or no gas is evolved during pouring. Following cooling, molds are broken up and castings are solution annealed. Where necessary, machining should follow annealing and precede the low-temperature aging treatment, which produces maximum properties.

Investment—Investment or "lost-wax" casting provides a comparatively new method of casting small, precision parts. This process frequently presents outstanding cost-saving and design opportunities.

Precision castings produced by "lost-wax" method. The unexcelled casting properties of beryllium copper insure maximum detail with minimum machining.

To prevent misapplication, engineers should carefully consider the following points:

Advantages

1. Reduced costs through accurate reproduction of detail in "as-cast" parts without machining.
2. Reduced costs through soft metal dies for short runs up to several thousand pieces.
3. Reduced costs through flexibility of design, permitting the combination of several sub-assemblies to give final parts not otherwise obtainable.

Disadvantages

1. Relatively simple and symmetrical shapes can be produced faster and cheaper by automatic machining methods.
2. Cannot compete pricewise with sand castings requiring few finishing operations.
3. For large parts, sand castings provide equivalent accuracy at lower cost.

By virtue of its unexcelled casting characteristics, beryllium copper is finding increased use in electrical, mechanical and novelty parts produced by the investment casting method. Long, thin cores, knife edges, relatively large flat areas, blind holes and narrow slots are typical of the sharp detail obtainable in "as-cast" parts. In addition, dimensional tolerances can be held to 0.002 in. per in., wall thicknesses

range from 0.030 to 0.250 in., and holes as small as 0.020 in. can be produced in light sections. Relatively low pouring temperatures permit the use of an easily and economically handled investment, which is in contrast to ferrous and nickel-base alloys having high melting ranges.

In comparison with steel, beryllium copper offers superior corrosion resistance and conductivity, and compares favorably in strength, hardness and wear resistance. Moreover, beryllium copper gives better detail, smoother surfaces and closer dimensional control. Compared to other copper-base alloys, beryllium copper parts are stronger and give better resistance to wear and moderately elevated temperatures.

Steel or soft metal dies, depending upon the number of parts and intricacy of detail required, are used to form wax or other low-melting patterns. After the surrounding investment fills the mold and hardens, heat is used to remove patterns. The metal is then poured either by gravity or centrifugal methods. The 2.0% beryllium content material (Alloy No. 20) has been found to offer the best combination of properties for investment casting.

Processing

Machining—High strength alloys (Nos. 20 and 275) are generally machined prior to hardening in either "as-cast" or solution-annealed conditions. Unhardened beryllium copper can be machined in a manner similar to other non-leaded copper alloys, such as tin or silicon bronze. The lower strength and hardness of the high-conductivity alloy (No. 10) permits machining in either unhardened or hardened conditions. Finish grinding of all alloys usually follows heat-treating.

All of these alloys can be readily machined with proper tools, speeds, feeds and cutting fluids. High-speed steel tools can be depended upon to give good service for heavy and intermittent cuts at moderate speeds, while carbide tools offer higher production rates over long runs. For best results, castings should be machined with moderate to high speeds and light feeds.

Through the proper selection of cutting fluids, efficiency can be materially increased. Soluble oil emulsions should be used where heat removal is of primary importance. Mineral lard oils give added lubricating properties; however, sulfurized mineral lard oils provide the best combination of lubricating, penetrating and surface-finishing characteristics. Sulfurized oils will stain beryllium copper unless parts are cleaned immediately following machining.

Since an abrasive oxide layer forms on beryllium copper when heated in uncontrolled atmospheres into hardening or solution annealing ranges, it is not advisable to take a light cut. The depth of cut should always be great enough to get under scale, unless oxide film has been removed by pickling prior to machining.

Heat-Treating—Although moderate properties are obtainable by heat-treating from the "as-cast" condition, maximum properties are available only through a two-step operation consisting of solution annealing and hardening.

High-strength alloys (Nos. 20 and 275) are annealed for at least 1 hr. per in. (or fraction of an in.) of section thickness at 1450 F, while the high-conductivity alloy (No. 10) is annealed at 1700 F. Castings are immediately water quenched upon removal from the furnace. Circulating air or muffle furnaces give good results; however, salt baths should not be used for annealing.

The hardening or aging heat treatment can be carried out in a muffle furnace, circulating air furnace or salt bath followed by uncontrolled cooling. Parts hardened in salt baths must be thoroughly cleaned upon removal from bath to prevent corrosion. Table IV lists recommended hardening times and temperatures and indicates the effect of heat treatment on the properties of beryllium copper casting alloys.

The age hardening feature of beryllium copper offers design advantages not available in casting alloys that do not respond to heat treatment. By varying hardening times and temperatures, different combinations of properties can be obtained, including strength, ductility, conductivity, and resistance to impact.

Cleaning—Oxide film formed on parts during annealing or hardening can be readily removed by the following pickling procedure:

1. Immerse in 20% sulfuric acid solution heated to 150 F until dark scale disappears.
2. Rinse in cold water.
3. Bright dip in 25% cold nitric acid solution for 15 to 30 sec.
4. Rinse in hot water and dry.

Castings are also frequently sand blasted to give a clean, uniform surface.

Table IV—Effect of Heat Treatment on the Properties of Beryllium Copper Casting Alloys

Alloy	Condition	Tensile Strength, Psi.	Elongation % in 2 In.	Rockwell Hardness	Electrical Conductivity % I.A.C.S.
20	As cast	80,000	22	B80	15
	Cast and heat treated (4 hr. @ 600 F)	105,000	8	C28	20
	Cast and solution annealed (1450 F)*	60,000	30	B60	12
	Solution annealed (1450 F)* and heat treated (3 hr. @ 600 F)	160,000	2	C40	25
275	As cast	105,000	17	B95	12
	Cast and heat treated (4 hr. @ 600 F)	120,000	5	C30	15
	Cast and solution annealed (1450 F)*	80,000	22	B75	10
	Solution annealed (1450 F)* and heat treated (3 hr. @ 600 F)	175,000	1	C43	22
10	As cast	60,000	25	B60	30
	Cast and heat treated (4 hr. @ 900 F)	75,000	10	B75	38
	Cast and solution annealed (1700 F)*	35,000	35	B30	23
	Solution annealed (1700 F)* and heat treated (3 hr. @ 900 F)	95,000	8	C22	45

** 1 hr. per in. of section thickness. Minimum time, 1 hr.*

Simplified Methods of Cleaning Metals for Plating

by JEROME L. BLEIWEIS, Metal Finishing Consultant

Although certain cleaning jobs require special compounds, most shops could do the bulk of their final work with a heavy duty cleaner and moderately alkaline compound.

● BEFORE WORK WHICH is to be electroplated can be processed successfully, the surface of the work must be "clean." Cleaning here is referred to as that process or sequence of processes which removes organic and other contamination from a metallic surface preceding the pickling and plating stages of the total sequence. Cleaning can be broken up into the precleaning stage and the final or alkaline cleaning stage.

The precleaning stage has as its function the removal of the more than superficial and particularly the heavy oil and grease layers from the surface of the work. This is done previous to a mechanical finishing operation such as polishing, before some pickling operations such as bright dipping of brass, and frequently before the final alkaline cleaning previous to plating in order to minimize the final cleaning time and to introduce as little contamination as possible into the final cleaner.

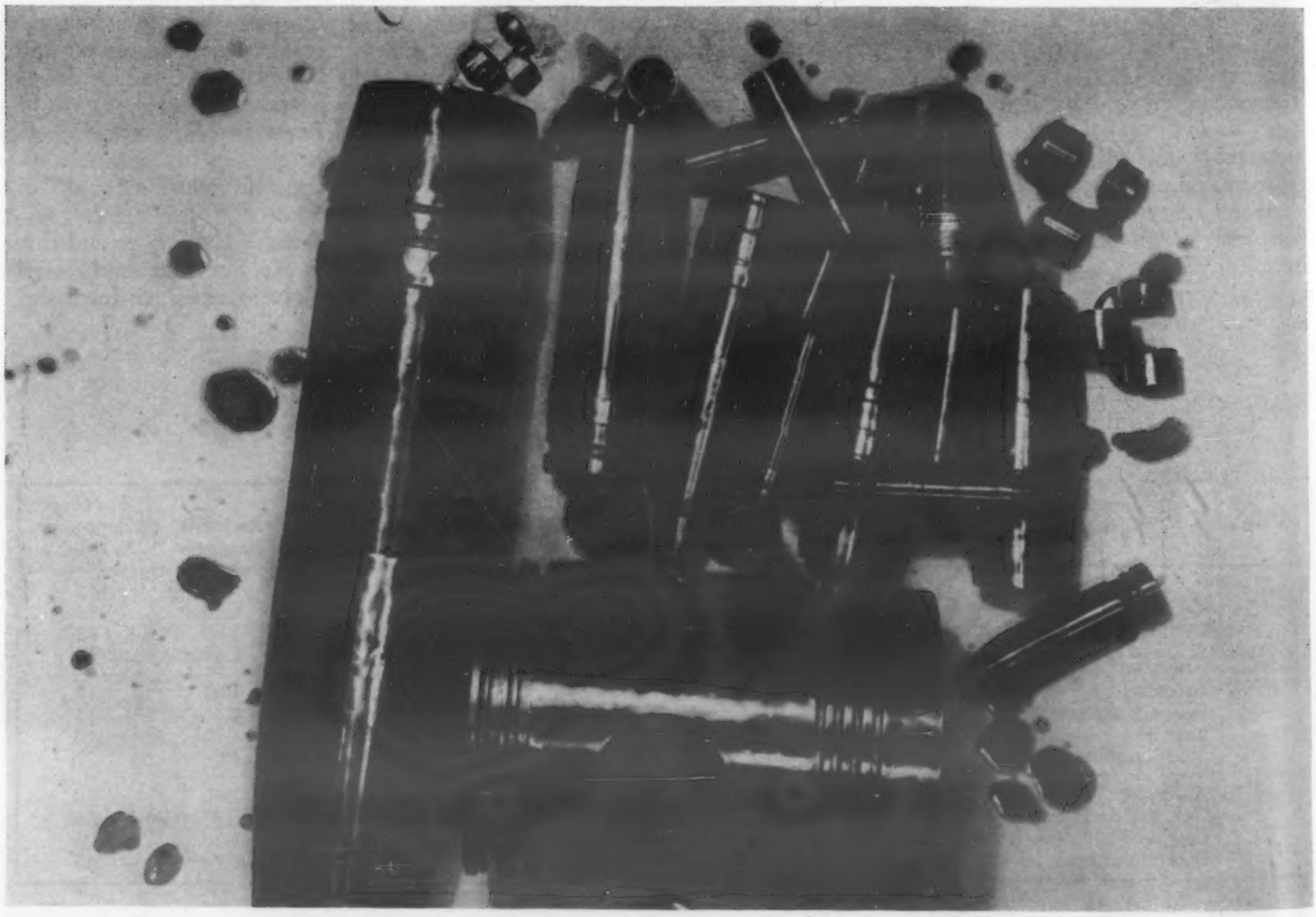
Precleaning Methods

There are three types of chemical precleaning agents: organic solvent; emulsion; and alkaline.

The organic solvent type of precleaning operation has as its function the removal of grease or oil layers or suspensions in grease, wax, or oil from the surface of the work to be plated by dissolving the organic contamination and thereby reducing its concentration on the surface. The materials generally used are the nonflammable chlorinated degreasing solvents such as trichlorethylene or the organic spirits solvents which are inflammable.

Chlorinated solvent degreasing is performed commercially through the employment of any one or combination of the three available methods, namely the vapor, immersion, or spray methods of degreasing. In the vapor method, distilled hot chlorinated solvent vapors condense on the cool work immersed in the vapor space

Here are a group of parts as they came from the machine shop, covered with coolant and protective grease.



and dissolve the oil and grease from the surface. The oil or grease-solvent solution rains back into the boiling liquid chamber where clean solvent is again distilled. This method yields the cleanest surface and is generally the final stage where a combination of degreasing methods is used.

Immersion degreasing involves dipping the work in a boiling solvent. This method is advantageous in that the agitation of the boiling solvent creates a mechanical cleaning action which expedites the removal of heavy contamination. The work is generally solvent or vapor degreased again subsequent to this operation.

Spray degreasing involves the use of sprays of warm solvent distillate directed under pressure at the work. The physical action results in the removal of insoluble particles as well as the soluble grease and oil layers. Vapor cleaning is frequently a final operation.

Degreasers, machines constructed to perform any of the degreasing processes mentioned, are essentially thermally balanced open stills heated at the bottom and provided with cooling media near the top of the side walls to control the height of the vapors. The still box is generally constructed of galvanized or zinc plated steel sheet for increased corrosion resistance. A trough located under the side wall cooling coils collects the condensed solvent and directs it either back into the liquid chamber or to another chamber for immersion or spray purposes. The effective vapor-spray-vapor degreasers clean by first wetting the work with solvent vapors after which the warm solvent is pressure-sprayed on the work thus removing caked-on soil; finally, a pure vapor stage removes all remaining oil and grease. This combination type of machine is particularly useful on large parts and large size assemblies.

Petroleum spirits are frequently used for precleaning or sometimes for final cleaning where no plating or finishing operations are to be used subsequent to the degreasing. Machines incorporating petroleum spirits are largely used in the cleaning of aircraft and automotive parts. Warm spirits are sprayed on the work being conveyed through the machine. They are effective in the removal of soil in which all kinds of solid matter is imbedded. Machines using petroleum spirits are designed with considerable attention to safety features to minimize the dangerous possibilities accruing from the use of flammable liquids. Therefore automatic carbon dioxide units, exhaust systems with safety dampers and doors, explosion proof motors and electrical accessories, non-sparking moving parts, and enclosed drives are incorporated in machines employing petroleum spirits.

Emulsion type cleaning solutions utilize stable water petroleum solvent emulsions which are used to remove many insoluble contaminants through emulsification. They are characterized by their ability to remove caked-on materials, heavy grease and oil, and insoluble materials without chemical attack on the surface of the metal. The film of oil which is left after emulsion cleaning acts as a rust inhibitor and is valuable where the cleaned work might be stored before further processing. Wide ranges of concentration and temperature can be employed in the operation of emulsion cleaners. Machines using emulsion cleaners are similar to those using petroleum spirits, but the fire hazard is not as great. Spray or immersion cycles are applicable for emulsion type cleaners.

The same group of parts after degreasing preliminary to final degreasing. (Photos courtesy Detrex Corp.)

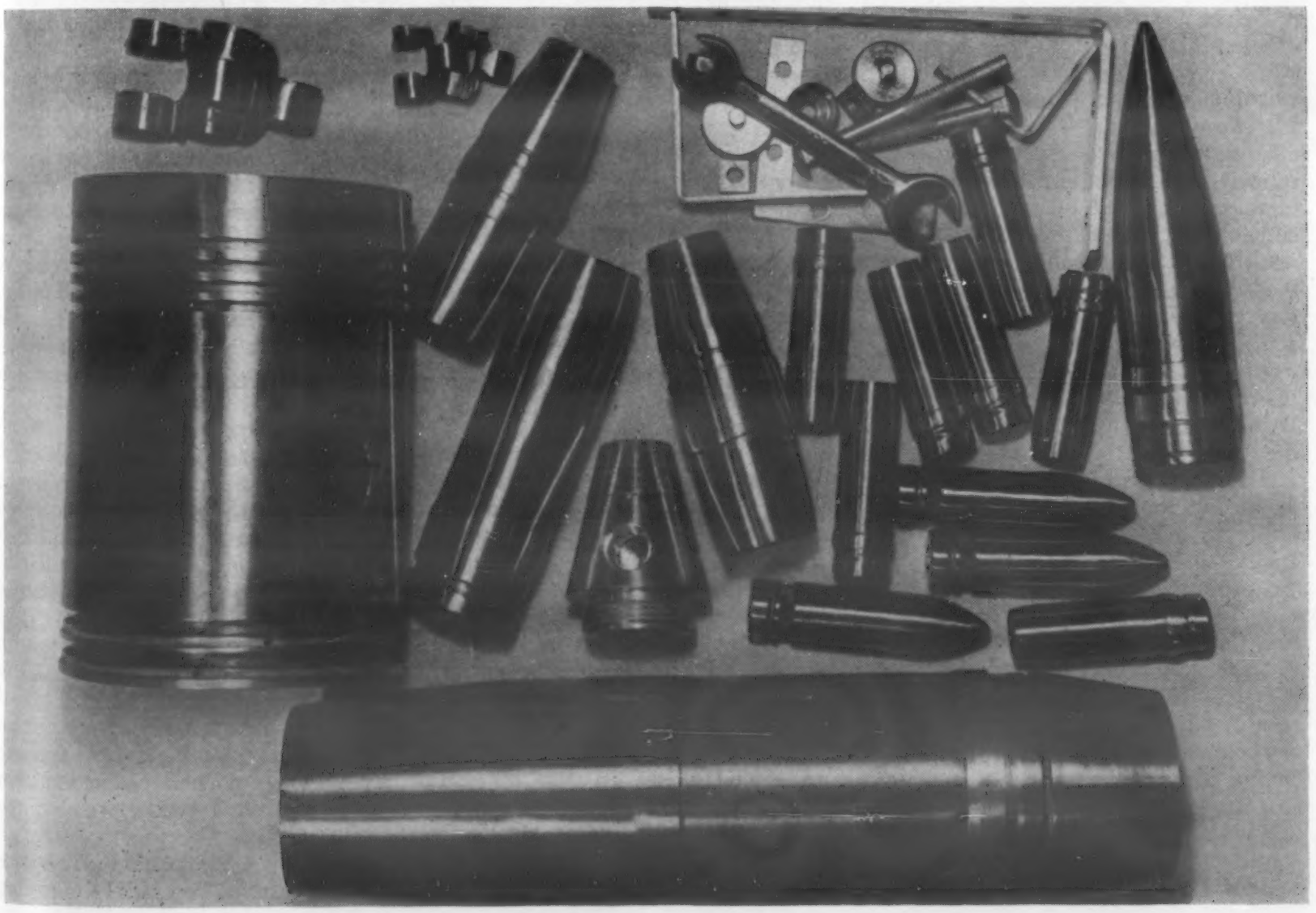


Table 1—Summary of Precleaning Procedures

Type	Method	Remarks
Chlorinated Solvent	Vapor	Leaves work cleanest. Generally used as final step in the precleaning
Chlorinated Solvent	Immersion	Boiling solvent physically aids in dislodging heavy soil
Chlorinated Solvent	Spray	Pressure spray method effective in dislodging soil
Chlorinated Solvent	Vapor-Spray-Vapor	Most effective total precleaning cycle. Chlorinated solvents are nonflammable
Petroleum Spirits	Sprayed (Generally)	Leaves thin rust-inhibiting film on work. Solvent is flammable. Immersion precleaning is also used
Emulsion Cleaner	Spray or Immersion	Removes many insoluble contaminants, caked on materials. Leaves film on surface. Cleans by emulsification
Alkaline Cleaner	Spray or Immersion	Cleans by emulsification and saponification. Spray method is highly effective. Immersion method may be electrolytic or non-electrolytic

The alkaline cleaners have their widest application as final cleaners before plating. Frequently, however, alkaline cleaners are used effectively as precleaners. The action of an alkaline cleaner is due to its ability to remove soil by emulsification or saponification. Alkaline cleaners are used hot (usually about 180 F) and applied by immersion or spray washers. Immersion cleaning can be electrolytic or non-electrolytic (soak).

Final Cleaning

Before any work can be plated, regardless of its past cleaning history, it must be alkaline cleaned. Alkaline cleaning is the only suitable method for cleaning before plating. During alkaline cleaning soil, such as films of oil or grease, or buffing and polishing films, are removed by saponification and emulsification. However, this does not completely explain the action of the alkaline cleaner on the metal surface. There are surface chemical reactions between the cleaner and metal during the cleaning process. Some of the more visible evidences of this will be noted below in the discussion of the cleaning of specific materials.

The writer in his experiences with setting up and operating plating and finishing shops has at one time or another used or tried to use most of the proprietary cleaners on the market. The most important consideration in the purchase and use of a cleaner is the proper method of using it, not in the limited sense of using it anodically, cathodically, or as a soak cleaner, but in the very practical use of the cleaner from metal to metal, shape to shape, combination of cleaning steps, and time and temperature considerations. Most cleaners, if used correctly, will be satisfactory except for those applications which require reactivity beyond the intrinsic limitations of the cleaner. There is no necessity for having a multitude of cleaners and cleaning setups in the same shop each having some specific application for which it is supposed to be particularly well suited. Any plating plant which finishes all of the commonly plated basis metals—ferrous, copper base alloys, zinc die castings, aluminum alloys, and lead base alloys—can satisfactorily clean all of these by the proper employment of just two alkaline cleaners occasionally supplemented by a good precleaning stage for the removal of the heavier and more obdurate films.

Certainly for all work coming off a coloring wheel, the proper use of the two cleaners is sufficient. The two types of cleaners which should be employed are the heavy duty highly alkaline compositions generally recommended for steel and suitable as anodic cleaners, for example, the Oakite 90 type; and the buffed moderately alkaline trisodium phosphate type cleaner of the type recommended as anodic cleaners for zinc die castings, for example, the Optimus 1A10 cleaner. The proper use of the two will be effective in the cleaning before plating of any of the basis metals mentioned. An occasional exception arises where a completely nonetching aluminum cleaner is required.

The two cleaners, depending upon their application, will be used as soak cleaners and as electrolytic cleaners, both anodic and cathodic. They also will be used in conjunction with each other. The two cleaning tanks, therefore, should be set up close to each other, with a work rod running down the center of each and a double pole double throw reversing switch across each work rod and tank which will act as the other electrode. Presuming the use of the two cleaners noted above, the concentrations of each will be 8 oz. per gal. in its respective tank; the temperature 180 F; the voltage 6-7 v. In electrolytic cleaning, throwing power and other electrochemical considerations are important enough so that work should not be suspended in the cleaner in a "bunch," but in approximately the manner in which it will finally be plated. This is accomplished automatically by the use of racks. Where work is wired, the wires should be transferred to simple wire bearing racks which will be transferred from tank to tank, the wires always hanging in the same relative position.

The individual cleaning procedures described below and Table 2 will be relatively "foolproof" from the point of view of providing a surface which will eventually plate without peeling or blistering. However, the procedures given can be modified by the omission of one or more steps if the work is reasonably clean to start with or if the surfaces to be cleaned are tubular rather than flat. The procedures described assume the average soil condition to which a cleaner will be subjected. Judicious use of the precleaner should be made where soil is heavy. The two cleaners will be referred to as "heavy," for the heavy duty cleaner and "light," for the buffered cleaner.

Steel—Carbon and many magnetic alloy steels are easy to clean, and the steps in the cleaning cycle are listed in Table 2. The cleaner, regardless of the length of immersion, does not etch steel surfaces and attacks them only superficially. If the "smut" produced by prolonged direct current cleaning is not removed during the reverse current stage, step 2 should be repeated after the rinse and pickle. Nickel plating can follow directly on the steel.

Brass, Bronze, and Copper—Copper, brasses, and bronzes of all compositions can be cleaned using the procedure outlined in Table 2. High brasses, which are frequently difficult to clean for nickel plating, will evidence a golden brown tarnish after the fifth step. Pickling in 5 to 10% muriatic acid will remove the tarnish leaving a clean bright surface. After rinsing, the work can be nickel plated directly without having to resort to a preliminary cyanide copper flashing step. This provides a visible example of the chemical action between the cleaner and the metal surface. The action, in this case, is promoted by the reverse current step in the cleaning

sequence. Without this step it is difficult to clean many brasses and frequently the copper "flash" must be included for satisfactory results. On buffed work, the fifth step is instrumental in removing finger marks from the work.

This procedure will result in the removal of a considerable amount of caked-on compound particularly on exposed surfaces, eliminating the necessity of careful coloring before cleaning. Successful results, on a production scale, have been achieved on many articles by cleaning and plating work which has only been cut with tripoli, the lime coloring operation being eliminated altogether. Too long a reverse cycle in steps 2 and 5 will result in considerable etching on brass. However, on bronze and copper the time is less critical.

Zinc Die Castings—The shorter the alkaline cleaning cycle on zinc die castings, the better. "Overcleaning" is responsible for many unfortunate plating results where zinc die castings are involved. During the alkaline cleaning, little caked-on soil will be removed because of the short cycle required. It is therefore necessary, through the employment of a suitable precleaning stage, to bring the work to the alkaline cleaner in a clean condition to start with. The highly buffed surface will become a somewhat dull gray in step 3 (Table 2), but the application of bright copper and bright nickel will restore the highly buffed luster.

Aluminum—Aluminum and its alloys can be cleaned satisfactorily by soak-cleaning in either the light or heavy cleaner. Etching will be accelerated in the heavy cleaner and so the particular application on hand should determine the cleaning cycle. As, in the case of zinc die castings suitable precleaning will be advantageous.

Lead and Lead Base Alloys—These alloys, of which "white" metal is a notable example, also are subject to overcleaning. There are few really good electrolytic cleaners for lead base alloys. The use of the light cleaner as a soak cleaner is highly satisfactory for the cleaning of lead. The work is dipped into the light cleaner quickly with an up and down motion for 8 to 10 sec. after which it is quickly pickled in 5 to 10% muriatic acid. Wherever possible, the work should be precleaned, particularly where buffing has preceded any contemplated plating. It would be well to note here that after alkaline cleaning and pickling in the above manner, the work can be nickel plated directly or cyanide copper "flashed" before nickel plating. The copper flash acts as a kind of information stage. Rebuffing is easily performed over flashed copper but is difficult once nickel has been applied. A bad looking copper flash plate becomes an indication that rebuffing is needed. A good looking copper flash is a go ahead signal.

Nickel Plated Work

A plating shop is frequently called upon to plate on work which has already been nickel plated. The final plate may be gold, silver, chromium or any other. Where the existing nickel plate is continuous and in good condition, the procedure used is merely to plate over the nickel. In other words stripping of this as received nickel deposit is not necessary.

Nickel plate must never be cleaned anodically, i.e. by reverse current. Such a procedure will coat nickel with a passive film from which all subsequent deposits will peel. The best procedure to use is listed in Table 2.

After step 2 the work should be examined for water breaks. This should be repeated after step 4. The cleaning cycle should be terminated at that step where water breaks on the surface of the work are no longer evident. If after step 4, water breaks are still visible the cycle should be repeated one step at a time until there are no more water breaks after the rinse step following the pickle.

The procedures for alkaline cleaning before plating, as outlined above, have been devised as a result of extensive practical work in the plating plant. It is possible to use several different cleaners in the same shop each having a specific cleaning function, but in the interests of cost economy, space economy, and the simplification of procedures, the two cleaners mentioned above used in the practical manner described will be more than adequate for almost all types of work.

Table 2—Summary of Alkaline Cleaning Procedures Before Nickel Plating

Basis Metal	Cleaning Cycle	Remarks
Steel	1—Cathodic clean in heavy cleaner 15 sec. to 1 min. 2—Anodic clean in heavy cleaner 15 to 45 sec. 3—Rinse and pickle	Repeat if necessary
Copper Base Alloys (copper brass, bronze)	1—Cathodic clean in light cleaner 15 sec. to 1 min. 2—Anodic clean in light cleaner 2 to 10 sec. 3—Rinse 4—Cathodic clean in heavy cleaner 8 sec. 5—Anodic clean in heavy cleaner 1 sec. 6—Rinse and pickle	Step 4 can be preceded by a flash (less than 1 sec.) anodic strike in heavy cleaner. Work should emerge from step 5 with a rich golden brown tarnish which pickles off in step 6
Zinc Die Castings	1—Preclean 2—Soak in light cleaner 5 sec. 3—Anodic clean in light cleaner 5 to 20 sec. 4—Rinse and pickle	The shorter the cleaning cycle, the better the final result. It is, therefore, advisable to include a precleaning step. Work emerges a dullish gray after step 4 but bright copper and bright nickel restore the luster
Aluminum	1—Soak clean in light or heavy cleaner 2—Rinse 3—Pickle in nitric acid 10 to 50%	Cleaning cycle is flexible
Lead and Lead-Base Alloys	1—Soak clean with agitation in light cleaner 8 to 10 sec. 2—Rinse and pickle	Overcleaning is harmful
Nickel Plated Work	1—Cathodic clean light cleaner 5 sec. 2—Rinse, pickle, rinse 3—Cathodic clean in heavy cleaner 2 sec. 4—Rinse, pickle, rinse 5—Repeat cycle if necessary	Overcleaning is undesirable. Anodic cleaning should never be used. Sign of satisfactory cleaning is absence of water breaks after rinse following pickle

Note: Light cleaner is buffered cleaner of the Optimurs 1A10 type. Heavy cleaner is the highly alkaline anodic type steel cleaner of the Oakite #90 type.

New Development Extends Use of Studwelding to Aluminum

by J. BLAND, Senior Welding Engineer and V. A. DIGIGLIO, Welding Engineer, Material Laboratory, New York Naval Ship Yard

This new end welding method for attaching aluminum studs eliminates drilling and tapping operations and should find many applications in industry.

● IN THE PAST, end welding, or studwelding as it is commonly called, has been restricted to use on steel. A recent development by the Navy Department now makes possible welding aluminum studs to aluminum plate. The method, which has already been used successfully for welding aluminum insulation studs to aluminum superstructures on ships, should find many applications in industry.

The material used for the stud is an aluminum—5% silicon alloy wire, 3/16 in. dia. A specially designed welding end is cold upset on the wire; the stud blank is cut to length and threaded as required. Chemical or mechanical cleaning of the formed and threaded stud then prepares it for studwelding. An accompanying figure shows the form and appearance of both the experimental and the finally produced insulation studs.

Studwelding of this size stud is limited to sheets or plates ⅛-in. thick or over. Burn-through occurs in sheets under ⅛-in. thick. No work has been done to date on other size studs, although it might be expected that smaller sizes could be applied to thinner sheets. There appears to be no limitation as to the type of aluminum alloy base material to which the stud may be studwelded. Satisfactory results were obtained on commercially pure aluminum, as well as on the several types of low alloy, aluminum-base structural materials.

The Process and Equipment

The process is basically similar to that used for studwelding steel. The principal difference is that the standard studwelding gun is modified to provide for the introduction of an inert gas such as argon or helium. The stud end is set 3/16 in. to 1/4 in. beyond the legs of the gun, which, with the standard internal spring in the unit, produces sufficient driving force to set the stud into the molten weld metal up to the base of the fillet. The gas adapter is made long enough to provide adequate gas coverage without interfering with the welding operation. Normally, upon completion of a weld, the edge of the adapter is about 1/16 in. above the surface of the plate.

The inert gas atmosphere protects the molten weld metal and insures the production of clean, essentially sound welds. The gas must be distributed uniformly around the end of the stud, and is required only during the period from a few seconds before the arc is initiated (for flushing out air) until completion of the welding cycle.

The rate of gas flow required for satisfactory welding depends both on the gas used and the position of welding. For example, higher rates are required for helium in the vertical position than in the overhead position of welding; the reverse is necessary for argon. Typical rates of gas flow are for helium, 4 to 7 cu. ft. per hr., in the overhead position, and 18 to 23 cu. ft. per hr. in the vertical position. Argon flow rates of 2 to 4 cu. ft. per hr. in the vertical position, and 10 to 12 cu. ft. per hr. in the overhead position have been found adequate. Depending on the actual number of studs welded per hour, the above gas flow rates are about four to six times the actual rates of consumption, in view of the relatively short welding cycles.

In addition to the studwelding gun, the auxiliary equipment includes a welding cycle timer and a source of welding current. The two available types of timers are either a.c. actuated

Original and final forms of aluminum alloy studs developed for studwelding.

(contactor coil) or d.c. actuated. In view of the relatively low arc voltages in the inert gas atmosphere, some chattering of the d.c. timer contactor might occur. The a.c. timer is considered preferable for this particular process, as the contactor operation is independent of the welding current or voltage.

The power required for studwelding the aluminum studs is d.c. reverse current obtained from a resistance panel connected into a 1000 amp. constant potential generator circuit. Standard 400 amp. motor generator units can be used for the process; however, they must have the characteristic of providing welding current without appreciable surge upon initiation of the arc. Operations conducted with motor-generator units have produced satisfactory results in general, but infrequently the arc fails to initiate.

Data derived from oscillographic records indicate the optimum welding conditions to be about 480-510 amps., 19-20 v. (arc) and 10-11 cycles (60 c.p.s. timing) for studwelding in an argon atmosphere, and 440-450 amp., 24-25 v., and 10-11 cycles for a helium atmosphere. It must be noted that these conditions reflect the circuit used to obtain the data; obviously other conditions such as cable length, type of generator, and to some extent rate of gas flow, will modify the values. In general, it has been found that the above conditions serve as an adequate guide for preliminary settings, and require only slight changes for the particular circuit being employed in production work.

Certain limitations appear to be inherent in the process, the reasons for some of which have not yet been determined. The extent of lifting of the stud, which establishes the initial arc length, is critical, and must be held to 1/16 in., ±1/64 in. The welding end should extend 3/16 in. to 1/4 in. beyond the tripod legs for optimum results. The current used should be within the range noted above, and represents that in the arc during the welding cycle. The time of welding is also critical, and must be held within plus or minus one cycle. Obviously, such conditions as grease, oil or paint on either the stud or the plate material must be eliminated for satisfactory results. Normal oxide coating on aluminum does not appear to affect the welding.

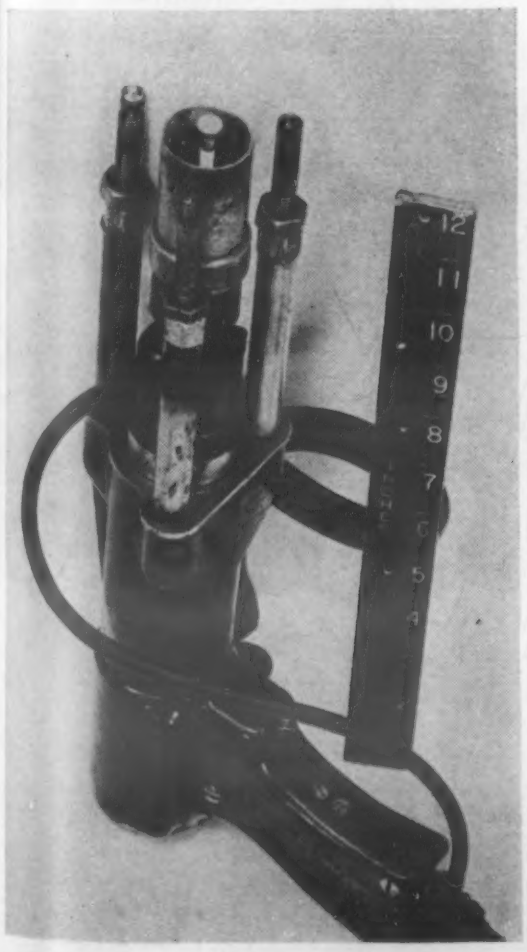
Properties of the Studwelds

The above welding conditions will studweld the aluminum insulation studs up to the base (largest diameter) of the fillet. Typical sections of welds are shown in the accompanying photomacrograph. Average mechanical properties determined are listed in the table and one of the figures shows the results of hammer bend tests on typical studs. From the test results it will be noted that the ultimate stress in tension ran between 18,000 and 19,000 psi. and in shear between 14,000 and 15,000 psi. These properties are essentially those of the stud body material, since there were no failures in the welds.

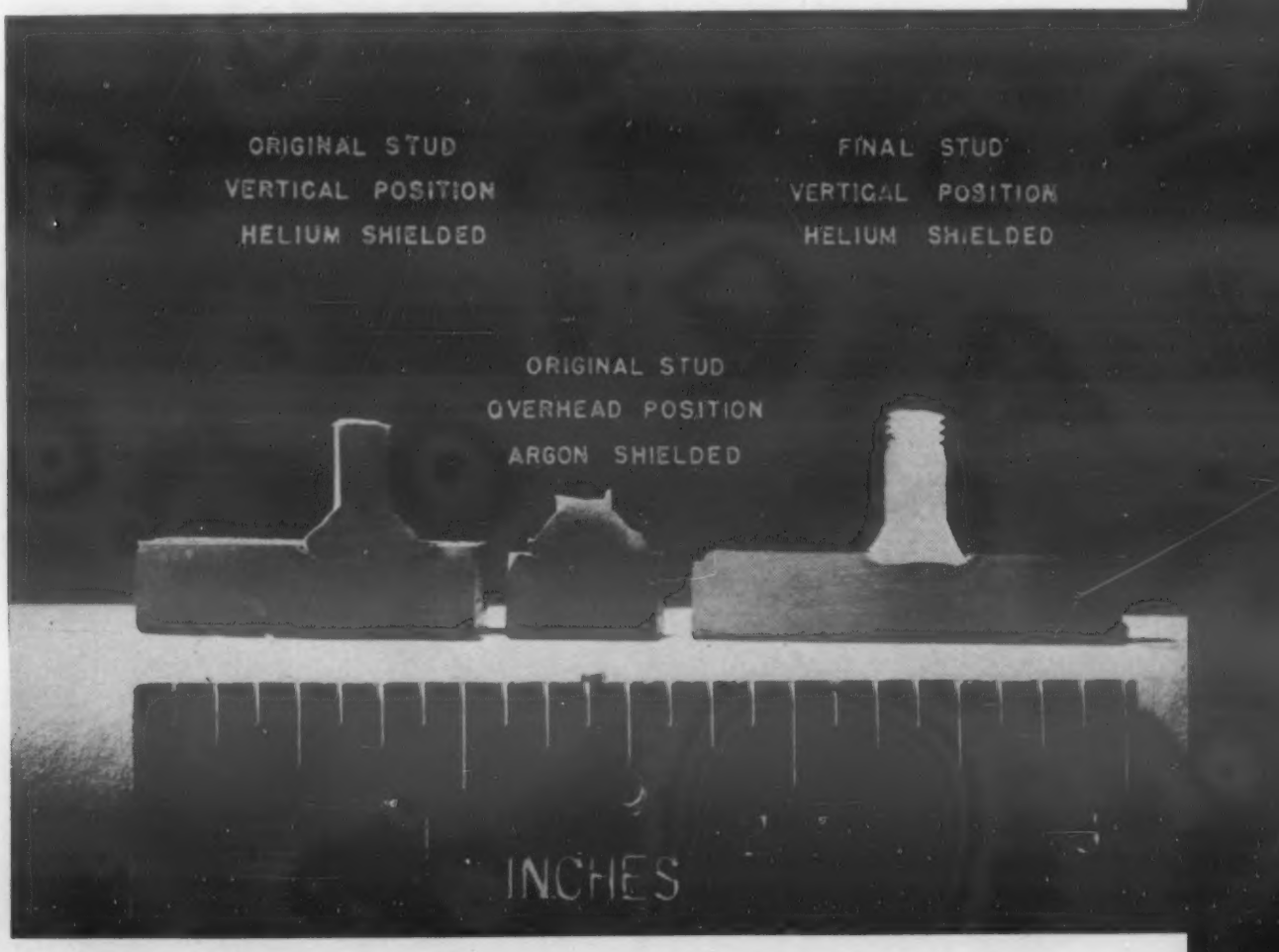
A consideration of the design of the welding end of the insulation studs indicates that unless an exceedingly defective weld is made, failure under loading must occur in the stud body. One of the primary reasons for the present design of the welding end is the fact that both the weld metal and the heat-affected portion of the stud are relatively brittle and lower in strength than the wrought aluminum material. For example, stud welds of a straight stud almost always fail at or near the weld when tested for physical properties. Therefore, by increasing the weld area and limiting the heat-affected zone to the enlarged base, the nominal physical properties of the wrought body material are made available.

One of the first production applications of this process required welding aluminum studs through glass-wool insulation already in place but inadequately secured. It was necessary to bore a ¾ in. dia. hole through the insulation, using a modified cork borer, into which a reduced diameter gas adapter could be introduced. Prior to welding, the aluminum alloy bulkhead or deck plate exposed through the hole, was cleaned of paint and

Close-up of studwelding gun showing gas adapter and aluminum stud.



Sections of aluminum stud welds using the original and final design of studs.



any metal remaining from the previous pin weld.

Preliminary tests indicated the necessity for maintaining the arc length (lift of stud) within the previously noted limits. The usual adapter for studwelding pointed steel insulation pins through insulation in place was found to provide insufficient rigidity of the welding gun for the aluminum studwelding. In order to secure the required conditions, the standard three-leg attachment was modified by turning down to ⅛ in. dia. about 1½ in. of the end of each leg, leaving the cone point. This permitted piercing of the insulation by the legs, and the gun was then maintained rigid by holding the ends of the legs against the bulkhead.

After the studs were welded and tested, the remainder of the enlarged hole was plugged with asbestos; a washer was then placed over the stud and secured in place with a nut. Cutting off the remaining exposed length of the stud flush with the face of the nut by means of end nippers produced enough distortion of the threads to prevent unscrewing of the nut in service. The whole surface was then painted. The holes pierced by the gun legs closed up sufficiently after removal of the gun to permit painting over without other preparation.

In this particular application, involving the difficult conditions attending repairs to vessels as well as requiring the instructions of personnel about a relatively new process, the results were quite satisfactory. Less than 5% of the total number of studs welded were considered unsatisfactory and required replacement. The largest portion of these defective welds were made during the early stages of the work. The overall rate of production was about 45 studs per hr.; this included time for moving equipment between compartments, preparation for welding etc. This rate can readily be doubled, at least, under normal production conditions, and defective welds could be eliminated almost completely with adequate care of equipment and training of personnel.

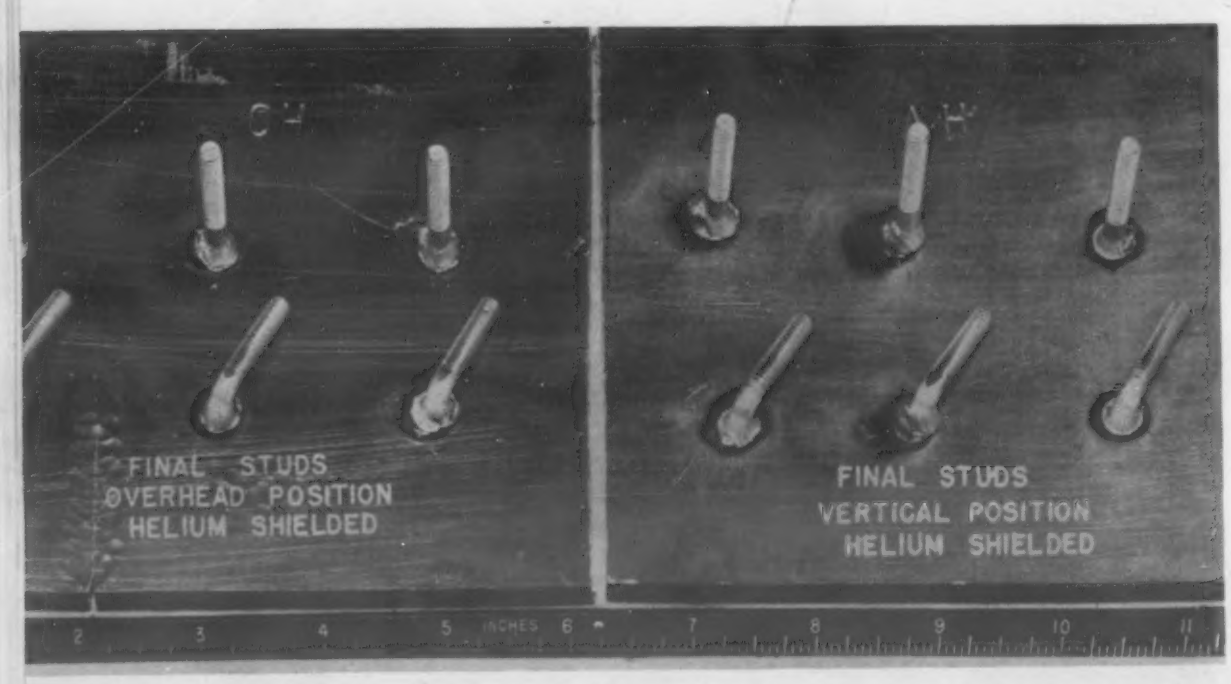
It should be noted that the adapter shown in the accompanying photograph represents a somewhat modified design of the unit originally devised and which was used for the above work. In addition, suitable equipment was developed to automatically delay the start of welding in order to permit the inert gas to flow and adequately flush the weld area. The gas flow is stopped coincidentally with the completion of the welding cycle. It is understood that the manufacturer of the studwelding gun used has available the necessary adapters and valve attachment which permits rapid changeover from steel to aluminum studwelding. In addition the valve attachment will obviate the necessity for separate equipment to time the gas flow.

The aluminum studwelding process has been applied on several other vessels with satisfactory results. These applications were made shortly after the original development of the process, and included only minor modifications of the equipment employed. A considerable amount of work must yet be accomplished in order to fully explore the full potentialities of studwelding aluminum. Such problems as larger size studs, higher strength stud materials, stud designs, and specialized welding equipment are of immediate concern and represent broad aspects for future development of the process.

Physical Properties of Aluminum Studwelds

	Stud No.	Load at Fracture, Lbs.	Ultimate Stress, Psi.	Fracture
Tension	1	495	18,000	Stud
	2	500	18,200	Stud
	3	530	19,300	Stud
Shear	1	415	15,100	Stud
	2	385	14,000	Stud
	3	390	14,200	Stud
	Stud No.	**Max. Torque Ft. Lbs.**	**Degree of Twist**	**Fracture**
Torsion	1	3.0	370	Stud
	2	3.0	300	Stud
	3	3.0	300	Stud
	15 Deg. Bend (Two Bends—Opposite Directions)		**Flat Bend**	
Bend	No Failures		No Weld Failures (Some studs failed on flat bending)	

Notes: Studs, 3/16 in. x 1½ in. aluminum—5% silicon alloy.
Plate, ¼ in. thick aluminum—1 magnesium—0.6% silicon alloy (heat treated).



Appearance of typical stud welds as-welded and after the hammer bend test.

Acknowledgment

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The opinions expressed in this article are those of the authors and do not necessarily represent the opinions of the Navy Department.

Flame-Sprayed Polythene Coatings Provide Exceptional Corrosion Resistance

—A NEW MATERIALS PREVIEW

• RESINS OF POLYTHENE (polymerized ethylene) have long been recognized as ideal coating materials for metal surfaces where corrosion is a factor. But use of these powder coatings has been retarded because of their virtual insolubility in liquids at ordinary temperatures. Early attempts to overcome this difficulty by flame spraying resulted in poor adhesion to the metal surface and excessive degradation. Development of new spraying techniques and equipment, however, by the Engineering Research Laboratory of E. I. du Pont de Nemours & Co., Inc., has eliminated most of these troubles and metal surfaces can now be coated successfully with polythene resins.

Severe exposure tests of one year's duration have shown no deterioration in these coatings by hydrochloric, hydrofluoric, sulfuric, and formic acids. Polythene films, modified with graphite, have been found to be free of porosity by spark tests in the neighborhood of 30,000 v., and various other short-time exposures to a variety of chemicals have been successfully withstood.

Such resistance to corrosion coupled with the newly-achieved ease of application makes possible widespread use of these polythene resins for coating storage tanks, drums, piping, valve gates, and the like, where conditions of both atmospheric and chemical deterioration exist.

The successful preparation of polythene coatings requires fusion of the sprayed powder in order to "wet" the target surface and to coalesce the particles into a continuous film. The powdered resin must thus be heated to its melting point and maintained at this temperature for sufficient time to permit complete coalescence. Since it is not always possible to produce a stream of completely molten undegraded polythene particles, some of the heat of melting must be supplied by the surface being coated in order to achieve perfect fusion. Accordingly, the surface is usually preheated to 400 to 500 F to provide the heat reservoir necessary for complete flattening and coalescence of the sprayed particles.

Method of applying polythene coatings. Work surface is preheated to assure complete fusion and coalescense of sprayed resin particles. (Courtesy E. I. du Pont de Nemours & Co., Inc.)

The adhesion of flame-sprayed polythene films to metal is dependent upon the condition of the surface prior to coating, and all dirt, grease or foreign matter must be removed for satisfactory results. Sandblasting is excellent for this purpose as it not only cleans the surface but roughens it so that the sprayed coating is more effectively bonded in place.

Adhesion is deleteriously affected if flame-sprayed; unmodified polythene particles are permitted to cool slowly in air after deposition. Water quenching of coated surfaces from the melt affords excellent adhesion, but such cooling is impractical for any but small articles. To circumvent this disadvantage, modifiers are often used. These, when added to polythene powder in small amounts, improve the adhesion of the flame-sprayed coatings to metal even when air-cooled. Finely powdered graphite or carbon black mixed with minus 60 mesh polythene powder in quantities of approximately 0.5% give most satisfactory results. But even with the addition of a modifier, preheating is necessary for an effective bond.

Stock can be preheated with either the flame-spraying gun or with a bank of standard torches, depending upon the size of the surface to be coated. The flame-spraying gun is handled and the coating applied in much the same manner as conventional spray painting. Areas measuring approximately 2 by 3 ft. in size are sprayed at a time, the torch being passed back and forth over the surface in a series of overlapping strips. After completion of one pass over the entire area, the process is repeated until the desired coating thickness is built up.

A gun flame 8 to 12 in. long is used, the tip of which is kept about 2 in. from the work surface. With this method of application, the particles will appear unmelted as they strike the surface to be coated but will immediately fuse down after being deposited in place. This slight lag is the time necessary for the complete melting and fusion of the newly-deposited material with the adjacent particles. The heat applied with each pass is sufficient to maintain the surface at the desired temperature level. Thus, reheating of moderate-sized areas is unnecessary once spraying has commenced.

With the desired thickness obtained, the coating can be glazed or polished by passing the flame over it in the same manner as in spraying but without the addition of powder. Extreme care is required in this operation, however, to avoid burning the finish.

Advantages Gained by Precision Casting Wide Range of Steels and Alloys

Precision casting is useful for high-production casting of many low-cost metals as well as for fabrication of intricate parts.

by K. J. YONKER, Precision Casting Section, Allis-Chalmers Manufacturing Co.

● PRECISION CASTING using wax patterns has found its widest acceptance as a high-production technique for producing small, usually intricate forms to close tolerances with good surface finish. The materials used, however, have usually been rather costly, with certain notable exceptions. Jewelers and sculptors kept the "lost wax" process as a going institution when foundries generally used it only occasionally, as for an ornamental piece that otherwise would have been difficult to cast with good finish. Recently, the process has been given wide use, and its advantages for high-production casting of the low-cost metals, or for high-accuracy casting a few pieces, have been utilized.

At the West Allis Works of the Allis-Chalmers Manufacturing Co., a precision casting section has been established to use for peacetime production the knowledge and experience gained during the war, when Allis-Chalmers started casting buckets for superchargers. Then the company used such high-temperature materials as Vitallium for this work.

Materials That Are Cast

Present work uses an extremely wide range of casting alloys, ranging from several types of cast iron through the low-carbon steels, the medium-carbon steels, the tool steels, stainless steels, aluminum alloys, brasses, aluminum and manganese bronzes, to the special high-temperature alloys, including Allegheny Ludlum's S-590.

In considering the precision casting of various materials, it should be noted that the cost of the metal is a minor item for small parts of cast iron, brass, and such steels as SAE 8620 and SAE 3140. It is slightly higher for the stainless steels, and becomes an important part of the cost with alloys of the type of Vitallium, Stellite, and the Hastelloys. For this reason it is good policy to use only the purest of raw materials in making up batches of alloys for casting. Standard compositions like the SAE 3140 used in turbine disks will give little trouble, but with the higher-carbon steels, loss of carbon can occur to a degree sufficient to cause trouble in heat treating. A mix can be made with high purity iron, adding whatever ferroalloys are needed to give the desired alloy content, and finally making up the carbon by the addition of charcoal pig iron.

The stainless steels can be precision cast without difficulty. The stainless iron of the 13% chromium type, corresponding to SAE 51410, will show higher shrinkage and usually a poorer surface than the 18:8 stainless compositions.

The high-temperature materials are usually quite difficult to work by methods other than precision casting. Alloys of this class can usually be cast by the methods given here, and without change of investment material. Certain of the newer materials in the group require special investment mixtures of higher decomposition point, and these have been discussed in other articles on precision casting. Vitallium, the Hastelloys, Stellite, S-590, etc., can be melted down from ingot supplied by the producers, and cast in the standard investment mixtures.

Advantages of a Diversified Shop

It is the opinion of Allis-Chalmers officials that a precision casting plant should be prepared to cast a wide variety of metals, rather than to specialize in only a few materials of related type. This is in contrast to practice in conventional foundries, where melting requirements and methods interpose a practical limitation to diversified casting. Thus, if a gray iron foundry finds it necessary to produce brass castings, it will be necessary to install completely different melting equipment, and usually to engage men with special training in handling the cuprous alloys. This is equivalent to setting up a new foundry, for new sand and new patterns will be required also.

Some of the advantages of the precision casting shop in diversified casting are:

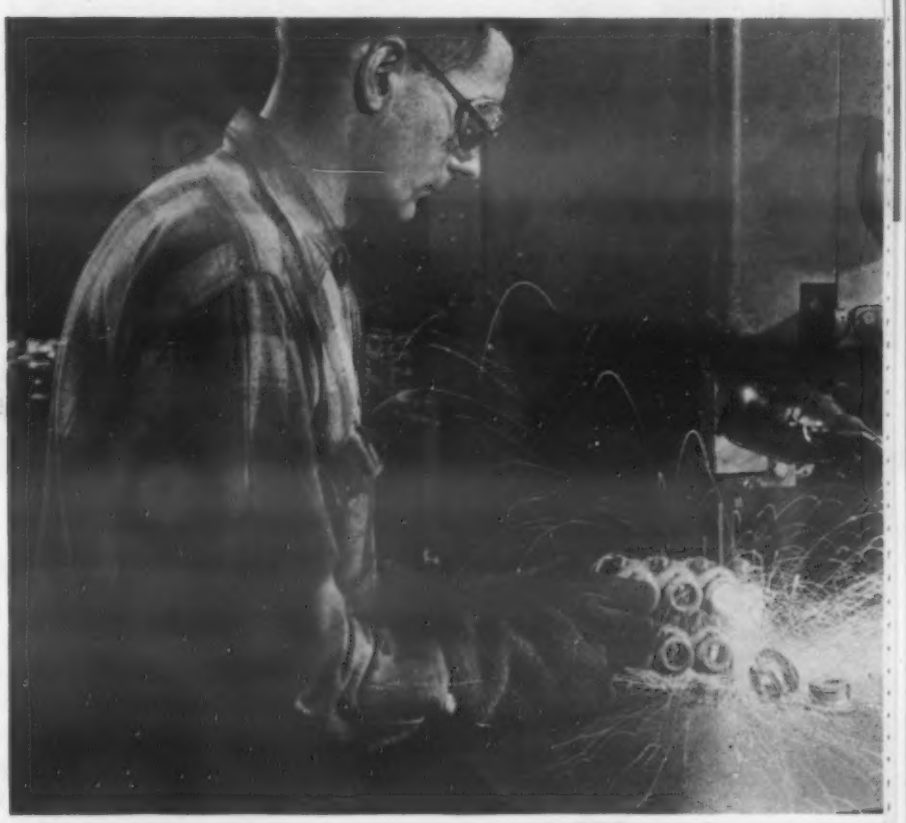
(1) The same melting equipment can be used for all materials. Induction melting is used at Allis-Chalmers, and is the rule elsewhere. The range of frequencies available in the radio-frequency types, as distinguished from the lower audio-frequencies and the higher ultrahigh-frequencies, will meet the needs of the melter of metals for precision casting.

(2) The same investment material can be used for most precision-cast metals. At Allis-Chalmers the investment is made from silica sand, ground firebrick, and magnesia. High temperature requirements may set a limitation to use of a single investment material for all metals; or the danger of chemical attack, as between magnesium alloys and Plaster of Paris, may make certain combinations unusable. For the most part, however, the investment can be used for the run of castable alloys.

Removing completed patterns from automatic wax injection machine, which produces patterns automatically in 2- to 3-min. cycles, with pattern removal and die lubrication as only manual operations.

Assembly of flask and pattern group. Pattern group has been attached to the bottom plate with wax. The alloy steel flask is placed over the pattern and sealed with melted wax.

Pouring the metal. The ladle holds complete charge from one furnace, enough to fill as many as five molds.



Cutting individual castings from the casting group with an ordinary blade that operates at speeds much greater than normal.

(3) Parts are small, encouraging the use of small batches in the melts. This is not always valid, as the runs may be large, and the total amount of metal required can be considerable. It is true in general, however, that batches of metal for precision casting will not exceed a few pounds. This gives an advantage to the precision casting shop for (a) production of single pieces or short runs of unusual analyses, and (b) close metallurgical control over the batch compositions.

In connection with melting by induction heating, some caution is needed in choosing the equipment best suited for a batch of metal. Frequencies at the lower end of the range, that is, about 1000 cycles, will produce rather violent agitation in small batches of metal, especially of the light metals. This is due to the magnetostriction in the charge. Favorable feature of these frequencies is the low power loss. They are most suitable for heating charges of 100 lb. or more, where the power input must be high, and where ebullition will not be too violent. With higher frequencies the magnetostrictive effect will be smaller, and power losses higher, so these frequencies are particularly suited to quick melting of small batches of metal.

The metals are melted down in much the same manner as in the ordinary foundry, except that the value of the piece will usually make it feasible to use a good grade of metal for melting. Less scrap is used with precision casting, and more

virgin metal of good purity and pure addition alloys. Carefully segregated scrap can be used for most purposes, as composition is little changed either in the melting furnace or during pouring or casting.

Parts produced by precision casting will ordinarily show physical properties slightly better than those for sand cast pieces. In the case of turbine blades, where forged blades were tested against cast blades of the same material, the cast pieces showed properties equal to those of the forgings, except for slightly lower ductility. Many of the pieces are used in the as-cast condition.

Precision Casting Blades and Buckets

The precision casting of blades and buckets for a small mud turbine is typical of Allis-Chalmers practice. The turbine in this case is used for oil well drilling, where the new rig using it features a turbine at the bottom of the hole driving the cutters instead of a rotary table located at the ground surface driving the long shaft as well as the cutter bit. The turbine is a 90-stage engine, with 90 rotors and 91 stators, cast as disks with blades or buckets an integral part of the disks. The rotors are keyed to the central shaft holding the cutters, which it turns, and the stators are keyed together to form the body of the turbine.

Both kinds of disks are precision cast of SAE 3140 steel, with the following analysis:

Carbon	0.40%
Manganese	0.80%
Nickel	1.25%
Chromium	0.60%
Iron and impurities	balance

The pieces are rather large for precision casting, the rotor disks weighing about 8 lb. each, and the stators about 12 lb. Therefore, the high production injection machine cannot be used on these pieces. As the pieces require no machining or other treatment over the contoured blades and buckets except a sandblast or similar cleaning, and only a simple facing operation along the sides of the disks, there is an obvious saving over methods of forming the blades and buckets separately and then assembling them into the disks.

The process begins with production of the wax patterns. These are cast in a steel mold, with the molten wax forced into the mold by means of a grease pump from a hot-water heated storage tank. The mold is held on the bench by an air clamp while the hot wax, at about 170 F, is injected into the mold from the nozzle of a hot-water heated hose. Another type of mold for the wax patterns uses lead-alloy cavities cast in a cast iron block, facilitating manufacture of the wax mold itself. A high-production molding machine for the wax patterns has been developed by Allis-Chalmers in which the wax is injected into water-cooled molds under high pressure from an automatically-operated gun, the press opens the molds automatically, and the wax gun is refilled from a hot reservoir. An alcohol-liquid soap solution is used for mold lubrication.

The wax patterns are stored in paper-lined trays, and wax sprues and gates are attached by hand when not a part of the pattern. Small patterns are assembled into "trees" on a sprue to obtain good production from each flask. The assembled pattern is then dipped into a thin slurry of fine silica and liquid binder, and dusted over with fine silica, building up a very fine-grained surface against which the metal will be poured.

Actual investing of the wax pattern is begun by attaching the top of the sprue to a steel plate with the pattern in an inverted position. A stainless steel flask open at both ends is then placed over the wax pattern on the plate. It is lined with waterproof paper, and, like the pattern, attached to the plate with hot wax. The flask is filled with the investment, which uses an ethyl silicate binder, and vibrated for a half-hour to settle the mixture. Excess liquid may then be poured off and the flask is set aside for about 10 hr. to dry.

The wax pattern is removed by placing the flask onto a steam table, where jets of steam directed against the sprue melt out most of the wax. After about 40 min. on the steam table the flask is placed in a tray and started into a gas-fired oven where temperature zones step up to 1850 F. The mold is dried for 8 hr., during which the last of the wax is burned out. The treatment can be accomplished at a lower final temperature (1400 F) by continuing the heating for 15 to 20 hr. At the end of this period the molds are preheated and ready for immediate pouring.

The flasks are removed from the furnace and placed onto a sand-covered rotating table for pouring. Small induction furnaces have melted the alloy steel, and pouring is done statically from a ladle in the same manner as in any steel foundry. Pouring temperature is about 2900 F. The rotating table can be turned by hand to bring each flask within easy working range of the ladle.

Cooling may require 5 hr. or more, but can be accelerated by directing an air blast against the outside or inside of the mold. The castings are then knocked out by an air hammer as the flask is clamped on a rack with an air clamp. A dust curtain catches most of the drifting dust. The gates are cut off with an ultra high-speed band saw.

A sandblast Wheelabrator cleaning completes the processing of the disks in the precision casting plant. The disks are heat treated to the top of the machinability range by quenching in water from 1600 F and drawing at 325 to 350 F. The turbine blades are buffed, then fine-grit blasted to develop a good finish.

Final inspection of castings, showing the wide variety of parts that are precision cast.

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

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Structural Parts from Metal Powders

by H. R. Clauser, Associate Editor, Materials & Methods

One of the important uses of the powder metallurgy process is in the production of structural or mechanical parts, and because of its numerous advantages, including high production rates and elimination of machining, it frequently competes with other forming methods such as machining, casting, stamping and forging. Whether or not a part should be made by powder metallurgy rather than one of these other methods depends upon the consideration of a great many factors. Therefore, this manual describes the various metal powders used for structural parts and discusses the selection considerations and design principles that the materials engineer should know about in order to intelligently appraise the possibility of using powder metallurgy for the production of his parts.

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Introduction

One of the youngest processes in the field of metal parts fabrication is powder metallurgy. It is not young in the sense that it was just recently invented, because metal powders have been used for a number of centuries, but young in an engineering and commercial way. It has only been the last ten or fifteen years that powder metallurgy has developed to the point where it can be used efficiently for more than just a few highly specialized items. And it was not until the war years that it expanded rapidly and demonstrated some of its far reaching possibilities.

Parts made from metal powders fall into two main groups. First, are those parts which can not be made by any other method. These include products made of refractory metals, highly porous structures such as self-lubricating bearings and metal filters, friction products and electrical contact materials which involve duplex structures. The second group of uses involves structural or mechanical parts where powder metallurgy is in competition with other metal forming methods such as machining, stamping, casting, and forging. Typical parts in this group include gears, cams, ordnance parts, a variety of ring and cylindrical shapes and any number of other different types of machine parts.

This manual will be concerned with only the second group of applications. It will cover the characteristics and properties of the various metal powders used for structural parts and will describe at some length the selection considerations and design principles about which the engineer should know in order to appraise intelligently the possibility of using powder metallurgy for the production of his parts.

Powder metallurgy is primarily a high speed production method for small parts, and like any other metal forming process it has definite capabilities and limitations which define its range of usefulness. Powder metallurgy should be carefully considered for parts which fall within its range, for the process offers a number of advantages. These advantages include among others: (1) Parts can be made exactly or rather close to final dimensions; (2) production rates are high; (3) in general, fewer operations are involved than is the case with many of the other forming methods; (4) labor costs are relatively low; (5) machining is not usually necessary; (6) there is little scrap.

The manufacture of structural parts by powder metallurgy involves two major operations: (1) pressing and (2) sintering. In the pressing operation metal powder is fed into a mold or die that is made to the final shape of the part. This loose powder is compressed under pressures generally ranging from 20 to 50 tons per sq. in. When the pressed part is ejected from the die, it has the appearance of the finished part. In this condition it is known as a "green" briquette or compact. It is weak and fragile and must be handled with reasonable care. Presses used in briquetting are either of the mechanical or hydraulic type. Dies and tools are made of either hardened steel or carbides and consist of a die cell or mold, an upper punch, a lower punch, and in some cases a core rod.

After pressing, the green briquette is sintered in an atmosphere or vacuum furnace at some temperature below the melting point of the metal powder. This bonds the solid particles together and provides the required properties. Time and temperature used depends upon the metal powders involved and the properties desired in the final product.

When higher strength, extra-smooth finish, or very close tolerances are required the sintered part may undergo a coining or sizing operation. This involves repressing the part in a die of suitable size. Coining or sizing is avoided whenever possible in the production of structural parts, because of the added cost.

Besides the steps described, other operations might be involved in the production of structural parts if special properties are desired. The parts can be impregnated or infiltrated with any one of a number of materials either during or after sintering.

Metal Powders

While there are a great number of different metal powders produced, relatively few of them have the particular combination of properties that make them suitable for mechanical parts. The powders most commonly used at present are iron and brass. In addition to these two, steel, bronze, copper, nickel-silver, and several special type powders are used to a relatively small degree.

A metal powder according to the definition of the American Society for Testing Materials is "an aggregate of discrete particles that are usually within the size range 1 to 1000 microns." The usefulness of a given powder for structural parts largely depends upon the properties and characteristics of these discrete particles as well as on their behavior when mixed and blended together. Important physical characteristics of metal powder particles include particle shape, particle size, hardness, sponginess or porosity in the particles, and particle grain structure.

Particle size and shape are governed largely by the method of production. They are produced in many shapes including angular, acicular, flat, rounded, granular, dendritic, or otherwise irregular. In many cases, the metal powder will be composed of several of these particle shapes, and almost always will consist of a number of different particle sizes. The hardness, sponginess and particle structure depends generally upon the type of metal, its purity, and method of preparation.

Selection Factors

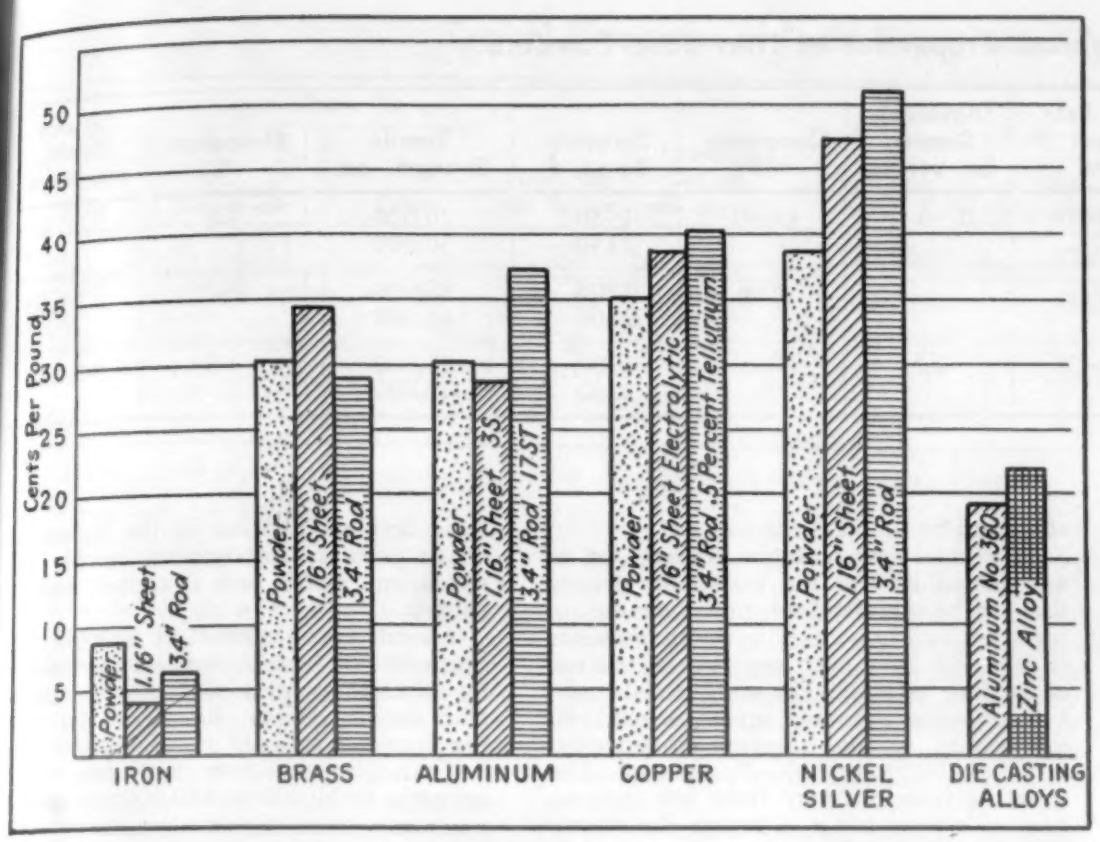
Selection of the metal powder to use in a given application depends on a number of factors. Purity of the powder is an important consideration. Characteristics of the powders which affect the actual fabrication of the part are also important. Cost is another important controlling factor. Finally, the powder in sintered form must meet the service requirements.

Purity—Clean particle surfaces are essential for good contact between particles if optimum mechanical properties are to be realized. In addition, the presence of foreign particles must be held to a minimum. In most cases definite limits for impurities are set by either producer or purchaser or both. In the case of iron and copper powders, there is a tentative standard method for determining the approximate insoluble matter content in the powders (Metal Powder Association Standard 6-48T). In addition, a standard has been set up to determine the oxide content in powders (M.P.A. 2-48T).

Apparent Density — Apparent density (sometimes called bulk density) refers to the weight of a unit volume of metal powder, usually expressed as gm. per cc. It is determined by filling a special container according to a specified method (refer to apparent density test, A.S.T.M. B-212-48 or M.P.A. 4-45). Apparent density is of particular importance in the pressing operation. The lower the apparent density the greater the volume of powder needed to produce a part of given size. This means that as apparent density decreases, deeper dies and longer plungers are required, and this can become a serious design problem.

Compressibility—The ability of a metal powder to be pressed is of importance both from the standpoint of fabrication and the end properties that can be attained. Compressibility is affected by the physical characteristics of the powder particles and distribution of particle sizes making up the powder. In general, powders should have a high enough compressibility so that satisfactory final density can be obtained without the need of using excessive pressing pressures. Compressibility is expressed as the ratio of the volume of the loose powder to the volume of the compact made from it.

Particle Size Distribution—This is also often called sieve analysis. It is usually expressed as the percentage by weight retained on each of a series of standard sieves



Approximate prices of metal powders vs. rod and sheet stock, as of Feb., 1949. (Courtesy The Lionel Corp.)

of decreasing size. Particle size distribution is an important factor and must be closely controlled because it affects a number of things including feeding into the press, dimensional changes during sintering, porosity of the compact, final attainable density, and strength properties. In general powders with particle sizes larger than 100 mesh are not used in production of structural parts. And usually the size distribution in commercial metal powders includes a range of particle sizes so that the fine particles will fill the voids between the large particles to give high density. While particle size distribution is one of the most important variables in powder metallurgy, it is also one of the most difficult to measure and control. At present particle size distribution can only be determined in commercial practice down to 325 mesh, whereas frequently 25 to 50%, and sometimes more, of a given powder is finer than 325 mesh. A standard method of sieve analysis of granular metal powders (approximately equidimensional nonspherical shapes) has been set up (A.S.T.M. B214-48 or M.P.A. 5-46), and a method for determining size and quantity of subsieve particles is now in process of being prepared.

Flow Rate—The ease with which a metal powder can be fed into the die is determined by its flow rate. Low flow rates slow up automatic pressing operations and may require the use of vibrating equipment. Flow rate is influenced by particle shape, particle size distribution, and amount of absorbed moisture in the powder. Flow rate is usually expressed in grams per min.; it is determined by measuring the time required for a powder sample of standard weight to flow through the orifice of a standard Hall flowmeter funnel. The procedure is given in A.S.T.M. B-213-48 or M.P.A. 3-45.

Sintering Properties—Sintering is usually done in an inert, reducing, or neutral atmosphere, or in a vacuum. The sintering temperature of metal powders is critical, and for production purposes, it is desirable to have a reasonably wide temperature range which can be maintained in presently available furnaces.

Dimensional changes occurring during sintering are also an important consideration, particularly from the standpoint of die design and the finish tolerances that can be maintained. The dimensional change brought on by sintering usually consists of shrinkage, although with some powders and under certain conditions expansion of the compact takes place.

Green Strength—A metal powder in the pressed but unsintered condition is rather brittle and is susceptible to chipping or other damage. Therefore, a metal powder must have sufficient strength to be handled without breakage before the sintering operation.

Performance Properties—The mechanical and physical properties are closely tied in with the final density that can be achieved with a given powder under practical pressing pressures. In general, as density of a metal powder part increases, strength properties also increase, and at 100% density the properties theoretically will be at least equal to those of solid stock.

Finding reliable means of measuring and evaluating performance properties of metal powder sintered parts is no easy matter. As yet few standard tests for determining mechanical properties have been established. And in many cases, the conventional methods are not adequate. The regular tensile strength test on standard specimens, for example, will not always give an accurate indication of the strength properties of the part, because of greater variations of final density in the part itself as compared to that in a tensile specimen. Hardness test results can also be misleading if tests are conducted in the same way as on wrought stock. Since metal powder parts are relatively porous, microhardness tests, which show hardness of the particles, are perhaps the most accurate. The Rockwell superficial hardness method is also frequently used; also the Brinnell test using the 10 mm. ball.

It should be understood then that in many cases parts should not be designed or ordered on the basis of conventional testing methods. Tensile strength or ductility can be meaningless in certain applications, since the standard tests do not always accurately evaluate these properties.

Iron-Base Powders

Iron-base powders are at present the most widely used material for structural parts. While 100% iron powder is used in some cases, most frequently other elements are added to obtain the desired properties.

Iron Powders—Most iron powders used in the production of structural parts are of the reduced type. The powder particles are of a porous or "spongy" nature, and are more or less irregular in shape. These particle characteristics provide powders that have satisfactory green strength, and favorable pressing and sintering properties. In addition to these particle characteristics, the powders must be of high purity for satisfactory results. For this reason, powders with iron contents of no less than 97% are most generally used for present applications. The iron content usually runs between 97 and 99% with the remainder of the composition consisting of carbon, silica, phosphorus, sulfur, and manganese.

The sieve analysis of iron powders varies considerably depending on the producer. The most common ones will pass a 40 mesh sieve and will have from around 20 to 50% pass through a 325 mesh screen. Since producers of iron powders can vary the sieve analysis and composition to meet specific sets of requirements, there are a great variety of types available. Also, annealed type iron powders are produced for use where extra high purity and closely controlled uniformity are needed to meet special requirements.

The sintering temperature of iron base powders ranges from around 1650 to 2150 F and the pressing pressures from 20 to 50 tons per sq. in. Increasing the sintering temperature and/or time, and increasing the pressing pressure tends to increase the finished density which in turn means increased mechanical properties.

In the accompanying table are listed the range of properties generally found in sintered iron powder compacts using reduced powders. It can be seen that tensile strengths of from 20,000 to 30,000 psi., and elongations of from about 5.0 to 8.0% can be attained. Surface treatments in which carbon is added by means of the sintering atmosphere can be used to improve the surface properties of the compacts.

Pure iron powders are seldom used alone for structural parts. Small additions of graphite and copper are made, or impregnation methods are used to improve the performance properties of the finished part.

Iron-Copper Powders—At present iron-

Typical Properties of Iron Base Powders

	Composition %	Flow Rate, Sec. per 50 gm.	Apparent Density, gm. per cc.	Compressibility	Sintering Range, F	Tensile Strength, psi.	Elongation, %	Sintered Density, gm. per cc.
Iron	97 Fe min.	30-50	2.0 to 2.8	Good	1950-2150	20,000-30,000	3-8	6.0-7.0
Iron-Copper	2 to 11 Cu Bal Fe			Fair	1800-2400	30,000-45,000	½-2	5.5-6.5
Iron-Graphite	Up to 1 graphite Bal Fe	40-42	2.5	Fair	1900-2200	25,000-40,000	3-6	5.5-6.5

copper powders are the most widely used for structural parts. Adding copper to iron powder increases the strength properties of the finished part, improves corrosion resistance, and tends to increase hardness. The copper, however, makes parts somewhat less ductile.

Iron-copper powders contain from 2 to 11% copper. Since about 10% copper is the maximum soluble by iron at the melting point of copper, little is gained by using greater amounts. Brass can also be used as a means of adding the copper. Small amounts of graphite are sometimes also added. The sintering process, which is performed at temperatures of between about 1800 and 2400 F, causes a wetting and alloying action of the copper with the iron. The diffusion rate increases with temperature, so the highest practical temperature is used.

There are two types of iron-copper powders. The most commonly used one is a straight mixture of iron and copper powders. The other is composed of iron particles partially coated with copper. With the latter powder there is said to be no segregation of particles and less dimensional change takes place during sintering.

As pointed out above, iron-copper powder parts have higher strength properties than those of pure iron. Tensile strengths are considered to range between 30,000 and 40,000 psi., although higher strengths than this have been reported. For example, a 10% copper-iron powder sintered at around 2200 F for 10 min. is reported as giving a tensile strength of about 56,000 psi. (pressed at 30 tons per sq. in.). It is possible to obtain strength properties equal to those of pure iron powder at considerably lower sintering temperatures with iron-copper powders.

Iron-copper parts are generally not considered heat treatable. However, it has been found that very small sized parts can be hardened by quenching and aging.

Iron-Graphite Powders—Sintered powder parts can be made from mixtures of iron and graphite. Iron-graphite mixtures contain up to 1% graphite, the remainder being pure iron powder. When iron-graphite mixtures are pressed and sintered internal carburization results and gives a carbon steel structure. The final carbon content can range up to around 0.75% depending upon the amount of graphite in the original mixture. The carbon is not necessarily all in combined form. Generally some free carbon is present since complete diffusion does not take place except after very long sintering periods; also high concentration of carbides at the interfaces is characteristic of these compacts.

In general with graphite contents up to and including 1% the maximum density that can be achieved with practical pressing pressures is around 6.5; however, densities of over 7.0 have been reported by the use of higher pressures. In commercial practice pressing pressures up to around 40 tons per sq. in. and sintering temperatures of about 1900 to 2200 F are used. The sintering time can vary from less than an hour to several hours, although the shorter times are preferred for economic reasons.

Sintered iron-graphite parts have higher strength and hardness than those of pure iron, but they are usually quite brittle. Tensile strengths of pressed and sintered compacts can range from around 25,000 to 40,000 psi. depending on the graphite addition or carbon content; elongation runs between 3 and 6%. Mechanical properties can be further increased, of course, by repressing after sintering.

Prealloyed Steel Powders—Powders are now available which are composed of prealloyed steel particles. To obtain a homogeneous steel structure, it is not necessary to depend upon the sintering operation.

One method of producing prealloyed steel powders is by decarburization of steel shot of the proper composition. Medium carbon steel (0.7% carbon) powder made by this method is claimed to have a compressibility comparable to sponge iron. With a pressing pressure of 40 tons and a sintering temperature of 2100 F a tensile strength of 35,700 psi. is obtained. Another method of producing prealloyed steel powder consists of disintegrating a molten metal stream with water jets. The powder particles are spherical. Carbon steel as well as alloy steel powders can be made in this way.

Similar to parts made from iron-graphite mixtures, the strength and hardness of steel powder parts are higher than those of pure iron, while the ductility is lower. However, as yet prealloyed steel powders are not being widely used. Their relatively poor compressibility and low green strength present some processing difficulties that thus far have limited their application.

Impregnation — The relatively low strength properties of iron powder parts are largely due to the porosity of the compacts. For this reason, impregnating with any one of a number of different materials, both metallic and nonmetallic, has been tried with varying success. In many cases the most satisfactory impregnating materials and methods are not publicly known because they are kept as trade secrets by their developers. Some of the known materials used as impregnants include wax, resins, and metals such as copper, lead and babbitt.

An interesting method of improving the properties of iron or steel powder parts is by infiltrating the porous powder compact with molten copper. Relatively low pressing pressures are used and the final product is virtually pore-free and has tensile strengths of 50,000 to 100,000 psi. By heat treatments even higher strengths are possible.

While it is generally agreed that impregnation with various materials significantly improves performance properties, the method is still not widely used because of the added operations and costs. Nevertheless the use of impregnants is increasing, and present and future refinements and developments may lead to their much wider application.

Nonferrous Powders

Brass Powders—Commercial brass powders are produced by atomization. They are composed of prealloyed copper-zinc and are generally supplied in minus 100 mesh, with about half of the powder through 325 mesh. The particle shapes are either spherical or irregular. However, only those brass powders composed of irregular particle shapes are used in the production of structural parts. The irregular brass powders, with their rough surfaces and flaky or acicular projections, possess good mechanical bonding and provide green strength sufficient to permit handling of the pressed compacts before sintering.

Brass powders are available in a wide range of compositions, the copper content running from about 50 to 90% and zinc content running from around 10 to as high as 50%. The alpha brasses (70% and higher copper) have higher green strength than the harder beta brasses (65% and lower copper). Therefore, if the part is relatively complicated or has sharp contours, an alpha brass is the better choice. Final strength properties, however, are little affected by changes in copper content.

Probably the most important effects of copper content are on sintering range and temperature, and on change in weight and dimensions during sintering. In applications where control of weight loss and dimensional changes are very important there is every advantage to high copper content. Also the sintering range increases with copper content; therefore, high cop-

Typical Properties of Some Brass Metal Powders

Kind	Composition, %			Flow, Sec. per 50 gm.	Apparent Density, gm. per cc.	Sintering Range, F	Sintered Properties			
	Cu	Zn	Other				Tensile Strength, psi.	Elongation, %	Change in Length, %	Hardness
Brass	85	15		26	3	1580-1688	37,000	17	–0.6	—
Brass	70	30	0.3P	33 to (2)	2.6-3	1508-1580	36,000	48	–1.4	39 Bhn. (3)
Brass	78.5	20	1.5Pb	30	3.1	1580-1652	30,000	12	–1.1	—
Nickel-Silver	64	18	18Ni	29	3.1	1724-1796	44,000	10	–1.0	88R_h

(1) Compacts pressed at 50 tons per sq. in. and sintered at optimum temperature in dry hydrogen.
(2) Intermittent flow
(3) 10 mm. ball, 250 Kg. load

per powders are an advantage in this respect. In fact, if no phosphorus is present, powders with copper contents of less than 70% are unsatisfactory for commercial sintering.

Additions of less than 1% phosphorus to low copper brasses in the form of a phosphor-copper admixture reduces the optimum sintering temperature and broadens the sintering range. For example, in 70-30 brass phosphorus reduces optimum sintering temperature from 1652 to 1562 F and broadens the sintering range from 68 to 104 F. In addition, it improves ductility almost four times. On the higher copper brasses, phosphorus has little effect on sintering but does increase ductility of the sintered compacts.

As can be seen from the accompanying tables sintered brass powder compacts have tensile strengths up to around 35,000 and 40,000 psi. and elongations of from 15 to around 40% depending upon the composition, design and processing. In machinability, they are comparable to cast and wrought brass stock of the same analysis. To further improve machining characteristics 1 to 2% lead can be added. Where a coining operation is necessary, this also improves machinability.

While in the past serious difficulties were encountered in sintering brass powders, the source of these difficulties is now well known and precautions can be taken to avoid them. The most critical factor to control is the moisture content in the sintering atmosphere. To insure good results the moisture content must be held below 2% by volume. In general a pure hydrogen atmosphere is best for sintering, although various cracked gases have also given good results.

With special plating procedures, brass powder parts can be successfully plated. Coining decreases surface porosity and therefore facilitates plating.

Brass powders are being used for a variety of structural parts. They are particularly suited for applications requiring good corrosion resistance, and where free machining properties are desirable. Some typical applications include gears, brush holders, fuse washers, small clutch mechanisms, clock parts, and lock bodies.

Nickel-Silver—The metal powder commonly called "nickel-silver" is a copper-nickel-zinc prealloyed powder containing 18% nickel. Parts fabricated of nickel-silver have about the same tensile strength as those from beta brass powder, and slightly higher hardness. The sintering range is also much wider. Nickel-silver has even better corrosion resistance than brass and is more easily polished. Since it is more expensive than regular brass powders its use is limited to those applications where its recognized characteristics are essential. Some typical uses are for decorative medallions, contact lugs, and advance weights for magneto governors.

Other Nonferrous Powders — Copper and bronze powders find only limited use for structural parts. Their major uses are for filters, bearings, and electrical and friction products. Prealloyed bronze powders are relatively hard to press to the densities required to give satisfactory strength properties in structural parts. In addition, it is difficult to maintain close tolerances without a coining operation, because of the warping of bronze parts during sintering. Copper-tin powder mixtures have better compressibility than prealloyed bronze powders and therefore are more generally used. With these mixtures, a bronze part results by interdiffusion of the powders during sintering. Probably the most commonly used copper-tin mixtures contain around 10% tin. The strength properties of these powders are considerably below those of iron-base and brass powders, being usually below 20,000 psi.

Aluminum powder is beginning to receive some attention for use in making structural parts. An aluminum powder is now on the market which is reported to have properties close to those of wrought pure aluminum in the annealed condition. In this powder the oxide film on the particles is removed by an etching agent which then serves as the lubricant during pressing.

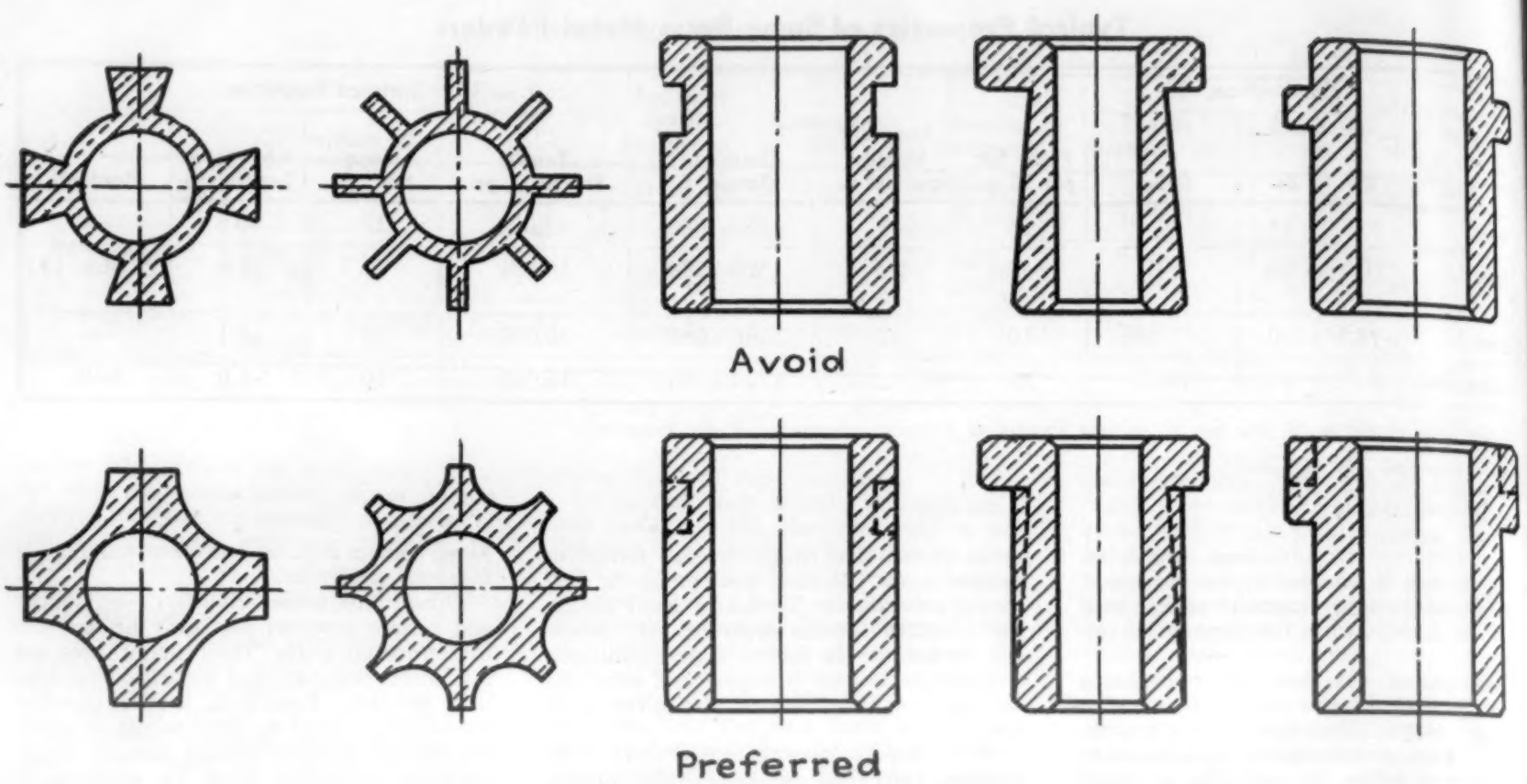
Structural Parts — Their Selection and Design

Whether or not a given structural part can be made at all by powder metallurgy methods or made better and more efficiently than by other means such as machining, casting, forging, and stamping depends upon the consideration of a large number of factors. The mechanical and physical properties that can be attained in powder metallurgy parts have already been covered in the previous section. This section will be devoted to discussion of the capabilities and limitations of metal powder parts from the standpoint of design and fabrication.

Much has been said and written about the advantages and limitations of powder metallurgy. But since the industry is still relatively young and still unsettled, there are in many cases wide differences in opinion on these matters. An attempt will be made here to set down the information gathered from the literature, personal interviews and a questionnaire to a large number of metal powder parts producers. The purpose is not to give exact and final design data, but rather to tell the engineer in a general way what can and cannot be done with powder metallurgy.

Quantity and Cost Factors

Powder metallurgy is primarily a high speed production process for relatively small parts, and to achieve low unit cost, large volume runs are usually necessary. A new die, and new punches are required for each part and these must be installed in the press and adjusted. This set-up time varies widely and may run as low as 1 hour or as high as 30 or more hours depending upon the type of part. The more complex the part the longer is the set-up time, and in some cases it takes more time to set-up



Typical design considerations for powder metallurgy parts. Top, designs that should be avoided; bottom, those that are preferred.

than to actually produce the number of parts desired.

Die costs vary widely according to the size and shape of the part and the die material used. Die costs of most fabricators questioned run from $100 to around $2000. Dies for single punch operations are, of course, less than when rotary presses are used. A simple small slug die may run no more than several hundred dollars as contrasted to around $2000 for a carbide gear or cam die.

Because of these high first costs, a run of 10,000 on a single punch press is frequently thought of as the minimum at which the process can operate economically and in competition with other methods. However minimum runs of much less than this (500 to 2000) have been reported as economical for certain parts. With rotary presses, the minimum run is much higher because of the higher die costs. Also, the smaller the part the greater is the volume required to pay for dies and set-up time. It is evident that as volume of the run increases, unit cost decreases. Consequently, applications where volumes run into the millions are favorable for powder metallurgy.

The cost of metal powders themselves is an important consideration. Metal powders often will cost more than the same metal for casting or in the wrought form. For this reason, powder metallurgy must prove its worth on the basis of such merits as its high rate of production, low metal loss, and elimination of machining cost.

Another cost factor which must sometimes be considered is the cost of experimental work. This is often necessary where a complicated piece is to be made with a material not used before in production. In such cases, more than one set of dies may be required because of design changes during development work prior to regular production.

Design Considerations

As mentioned earlier production of metal powder parts involves two major operations—pressing the part and sintering it. Of these two, pressing is the most critical from the standpoint of part design, and the feasibility of making a part by powder metallurgy frequently depends upon whether or not it can be pressed economically to the desired density.

There are two factors that limit the pressing operation and influence design. One of these is the lack of flow of metal powders before and during compacting because of friction between powder particles and between the particles and the dies and punches. This can prevent proper fill in parts of the die; this also presents problems of obtaining uniformity of density throughout the part. The other factor is that of tools and dies. Pressures are applied from the top and bottom only and this imposes certain limitations on shapes and certain design details.

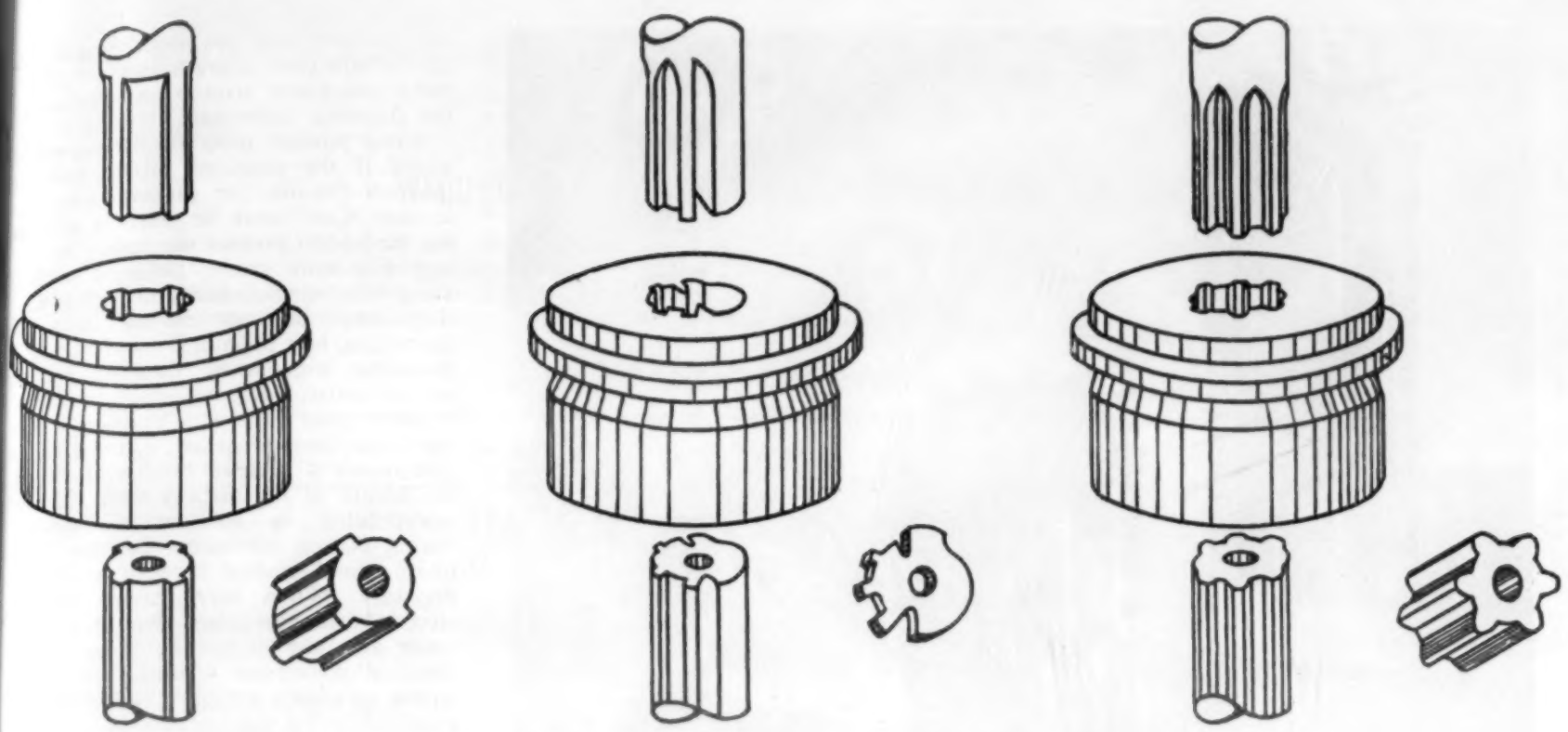
In discussing the design of metal powder parts, the dimension parallel to the direction of pressing is referred to as the length or axial dimension, while the dimension at right angles to the pressing motion is called the face or radial dimension.

Size—Powder metallurgy is a small parts production method. The maximum practical size is governed by a number of things including density required, compression ratio of the powder, pressing pressures available, and green strength of the powder used. The largest dimension of a great majority of structural parts ranges from less than an inch to several inches. With presently available pressing pressures satisfactory green strength and density cannot be obtained in parts which are over 2 to 3 in. in length. In respect to the minimum dimensions, parts have been made as small as 1/32 in. long and 1/8 in. at right angles to pressing.

The use of powder metallurgy on structural parts larger than several inches can lead to non-uniform distribution of pressure which upon sintering may affect the shape and dimensions of the part. In addition, large parts require large presses which usually are not of the automatic type, and which means lower production rates and increased cost. Another factor that limits the length of parts is the low apparent density of metal powders. In general, the compression ratio of metal powders used in structural parts is about 3 to 1. This means that the depth of mold or die cell must be at least 3 times the length of the pressed compacts.

Shapes and Dimensional Relations—The shapes that can be successfully made by powder metallurgy are governed largely by what can and cannot be done in the pressing operation. Consequently many of the limitations are quite similar to those encountered in other metal forming operations involving pressing equipment and dies. While a variety of shapes, sections and profiles are possible, the most suitable shapes are those which have uniform dimensions in the direction of pressing. These include simple cylindrical, square and rectangular shapes as well as odd shapes in which the contour is in a plane at right angles to the direction of pressing. For example, parts like cams and gears with radial projections and contours and no changes along the length are relatively simple to press by proper mating of the die cell and the punch design.

Since the molding dies are subject to enormous pressures, shapes that require a die of weak design should be avoided. Also the contour of parts should be such as to permit easy ejection from the die by means of an upward motion of the bottom punch.



Gears, cams and parts with projections or recessions are formed by mating the die cell and punch in the required shape. (Courtesy Moraine Products Div., General Motors Corp.)

Feather or knife edges, narrow and deep splines, and very small thin projections should be avoided. With such designs it is difficult to obtain satisfactory fill in narrow recesses, uniform density throughout the part is difficult to maintain, and the tools and dies are usually weak. In addition, parts are sometimes susceptible to damage when ejected from the press. True spherical sections are generally not practical unless there is a small land or flat of 0.010 to 0.020 in. on the centerline. This increases tool life.

Parts with holes in the direction of pressing are produced by use of a core rod which extends up through the mold and mates with corresponding holes in the punches. The hole can be of any shape including round, square, and other regular shapes, or it can be irregular such as a keyway. Tapered holes or counterbores can be produced by machining the core rod. In the case of tapered holes, a short length of the hole must be untapered to accommodate the upper punch. Holes not parallel to the length of the part cannot be pressed, nor can internal or external threads be molded but must be machined.

The minimum wall thickness that can be successfully pressed depends upon size of the part. Many fabricators report that the minimum wall thickness is around 0.030 in. for small parts that are up to ½ in. in dia. and ¾ in. in length; for larger parts the minimum wall thickness is of course larger. One producer reports a minimum wall thickness of 0.032 in. per 1 in. length, another 0.060 in. for each ½ in. of length, and another not less than 0.125 in. for parts up to 2 in. in dia. Large variations in wall thickness must be avoided for they can result in both pressing and sintering difficulties. During sintering unequal dimensional changes can take place and cause warpage.

The length or axial dimension of pressed parts is critical because of the problem of getting uniform density throughout the compact. If the ratio between axial and radial dimensions is too great the center portion is likely to be soft and weak. Where optimum uniformity and strength is required the length should be no more than the greatest radial dimension. However, in practice this ratio varies rather widely depending upon the performance requirements that must be met. A ratio of 3 to 1 in axial to radial dimensions is often used and sometimes it is as high as 5 to 1 and 7 to 1.

As was mentioned before, metal powder parts are pressed from the top and bottom and not from the sides. This, in addition to the fact that metal powders have almost no lateral flow, imposes certain limitations on parts having variations in axial dimensions. Such variations include flanges and steps, slots or grooves, reentrant grooves, and undercuts. If the axial variations are less than one-fourth the length, there should be no difficulty in pressing the part. If the variations are greater than this pressing from top and bottom or pressing in two movements may be necessary. On flanged parts and other one-step designs sharp corners should be avoided at the junction of the flange and body, and a minimum radius of 0.010 in. should be provided. Parts having several variations are somewhat more difficult to produce. However, parts with three different dimensions along the length are being successfully produced.

Parts having reentrant angles or grooves along the length, while not impossible to make with special side pressing techniques, are generally not considered suitable for powder metallurgy production.

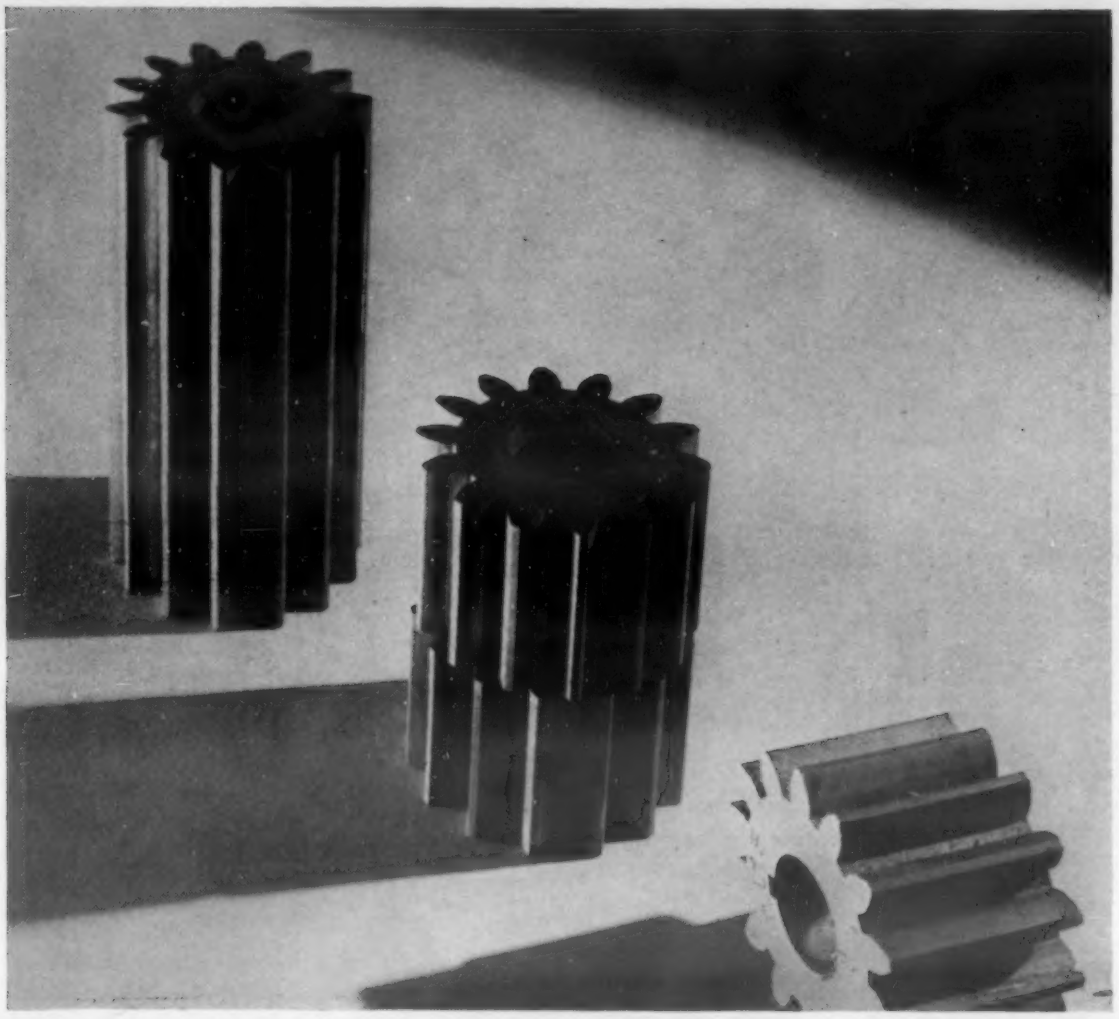
Tolerances—In general, the tolerances that can be held in the powder metallurgy process compare favorably with those of many of the other small parts production processes. Parts, in many cases, can be made to closer tolerances by powder metallurgy than by sand casting, die casting, stamping and forging.

Although structural parts can be produced to close dimensions, fairly liberal tolerances should be allowed wherever possible to keep costs down. For here as in other processes the closer the tolerance requirements the higher is the cost of production.

The generally accepted tolerance for the axial dimensions (in the direction of pressing) is ±0.005 in. and this can be readily met in production and without coining. Some fabricators report that tolerances of around ±0.002 in. can be held without extra operations. Radial tolerances are usually closer than those in the axial direction. They vary considerably depending on part size, die wear, etc. Reports from various fabricators show that this tolerance can run from about ±0.001 in. to ±0.002 in. On cylindrical parts standard eccentricity tolerance seems to be 0.003 to 0.004 total indicator reading.

Closer tolerances than those given above can be achieved at added cost by special control of the compacting and sintering operations, and by a coining operation. Thus, the length can be held to as low as ±0.001 in., and the radial dimensions to as low as ±0.0001 in. in some cases.

Other Design Considerations—It is important that the parts be made with beveled edges and with fillets on inside corners or angles. This increases tool life and facilitates pressing. The size of the fillets depends on part size, but normally should not be less than 0.010 in. Chamfers rather than radii should be provided on edges to avoid burring. Chamfers of 45 deg. can be used normal to pressing axis. On tapered parts, a small land at beginning of taper where



A group of typical gears fabricated of metal powder. (Courtesy American Electro Metal Corp.)

the tool stops prevents a feather edge on the tool.

Special Processing

While one of the outstanding advantages of powder metallurgy is that parts can be produced to finished form and dimensions, there are applications in which subsequent processing can be used to provide special or improved final properties. Therefore, these must be considered in studying the full potentialities of this small parts production method.

Heat Treating—Metal powder parts can be heat treated by many of the same methods employed on wrought and cast products. However, the results obtained are not strictly comparable. The porosity of the compacts and presence of films around the particles may result in less pronounced structural changes. Heat treating operations that can be applied include annealing or stress relieving, quench hardening, and surface hardening.

Steel powder parts can be heat treated similarly to solid steel products, but because of the porosity, greater care must be excercised to maintain a neutral and dry heat treating atmosphere. The heat treatment is frequently accomplished as part of the sintering operation, the parts being taken from the furnace and immediately quenched. Quench hardening usually gives improved strength properties and in some cases they closely approach those of regular SAE steels. However, their ductility and toughness remains considerably lower.

Iron-base powder parts can be surface hardened by carburizing, nitriding, and cyaniding. Carburizing is probably the most practical procedure, with both gas and pack carburizing being used. The depth of case depends, of course, on the carburizing medium and on the time. In general, diffusion of the carbon is wider and may extend to the core because of the porosity. Therefore, it is more difficult to control depth and uniformity of case.

Nitriding is accomplished in a dissociated ammonia gas atmosphere. Nitriding temperature is relatively low, but time may run up to 3 days. Cyaniding appears to be practical only on very high density parts. On relatively porous parts, the cyaniding salts readily penetrate the compact and cause internal corrosion to take place.

Machining—Metal powder parts can be ground or machined to maintain closer tolerances. Machining is also sometimes used as a supplementary operation to produce final shapes that cannot be obtained alone by powder metallurgy.

Sintered powder parts have poor machinability. The machining procedures are similar to those used on cast metals. The porosity of powder parts causes short chips to form and this must be considered in selecting the cutting tools and procedures. Machinability of iron-base parts can be improved somewhat by small additions of lead or copper-lead. Tungsten carbide tools give best results and will provide longer tool life. If parts are to be impregnated after machining the use of cutting coolants should be avoided.

Finishing—Practically all common finishing methods used on wrought or cast metal products are also applicable to metal powder parts. While methods and procedures in many cases are about the same, the special structural characteristics of powder parts sometimes require modifications in the finishing operations.

Metal powder parts can be successfully plated if the problems arising from the inherent porosity are properly taken into account. Care must be taken in selecting the method to prepare the surface for plating. Generally barrel polishing methods using relatively soft substance such as wood chips have been satisfactory. In buffing operations, best practice involves the use of greaseless compounds. Cleaning practices are, of course, quite important. In order to obtain a good plate, it is necessary to have the pores clean of grease, dirt and buffing compounds if present. Because of the porous nature of the surfaces there is greater susceptibility to solution contamination during plating operations. For this reason, more careful rinsing between solutions is necessary. When very porous parts are electroplated, the plate does not always cover over the surface pores and further chemical conversion coatings may be required to obtain complete corrosion resistance.

Other finishes that can be used on metal powder parts include phosphate coatings, organic finishes, dipped metal coatings and color treatments. A relatively new finishing method for powder parts is a steam treatment in which parts are exposed to a steam atmosphere at temperatures up to around 1000 F. On iron powder parts, blue magnetic iron oxide is formed. Because of the porous nature of the compacts, the oxide penetrates through the entire piece and improves its corrosion resistance. The oxide also increases surface hardness and wear resistance.

Welding—Little welding is encountered on structural parts made by powder metallurgy, and in general, only brazing and projection welding can be done successfully. To braze, special precautions must be taken to prevent the molten brazing metal from penetrating through the pores. One reported method of doing this is to quench the brazed part immediately after joining occurs.

Acknowledgment

The following organizations, through their literature or personal help supplied much of the information for this manual.

American Electro Metal Corp.
Amplex Mfg. Co., Chrysler Corp.
Bound Brook Oil-Less Bearing Co.
Charles Hardy, Inc.
Ekstrand & Tholand, Inc.
General Sintering Corp.
Johnson Bronze Co.
Lionel Corp.
Metal Powder Association
Metals Refining Co.
Moraine Products Div., General Motors Corp.
New Jersey Zinc Co.
P. R. Mallory & Co., Inc.
Plastic Metals, Div. of the National Radiator Co.
Powdered Metal Products Corp. of America
Powmetco, Inc.
Presmet Corp.
United States Graphite Co.
Wel-Met Co.

Materials Engineering File Facts

NUMBER 179
September, 1949

MATERIALS DATA SHEET

Wrought Stainless Steels—Martensitic Type

Martensitic-type stainless and heat resisting steels are primarily straight chromium steels having chromium contents of from 11 to 18%, with the exception of two types in which the chromium ranges from 4 to 6%. This group of steels responds to heat treatment similar to most lower alloy steels and, by suitable thermal treatment, develops a wide range of mechanical properties. As a group, they find use where good corrosion resistance and/or heat resistance combined with high mechanical properties are required.

Typical Properties

Property \ Type	403 410	414	416	420	431
COMPOSITION, %	C, 0.15 max. Cr, 11.5-13.5	C, 0.15 max. Cr, 11.5-13.0 Ni, 1.25-2.5	C, 0.15 max. Cr, 12-14 P, S or Se, 0.07 min. Mo or Zr, 0.06 max.	C, over 0.15 Cr, 12-14	C, 0.20 max. Cr, 15-17 Ni, 1.25-2.50
PHYSICAL PROPERTIES					
Density, Lb./Cu. In.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2700-2790	—	2700-2790	2650-2750	2650
Thermal Cond., Btu./Hr./Sq. Ft./Ft./°F, @ 212 F	14.4	14.4	14.4	14.4	11.7
Coef. of Exp. per °F:					
32 to 212 F	5.5×10^{-6}	5.8×10^{-6}	5.5×10^{-6}	5.7×10^{-6}	6.5×10^{-6}
32 to 1200 F	6.5×10^{-6}	—	6.5×10^{-6}	6.8×10^{-6}	—
Sp. Ht., Btu./Lb./°F:					
32 to 212 F	0.11	0.11	0.11	0.11	0.11
Elect. Res., Microhms/Cm./Cm.² (Room Temp.)	57	70	57	55	72
Magnetic Properties	Magnetic	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES					
Ten. Str., 1000 Psi.:					
Annealed	65-75	115-120	75	95	125
Hard. & Temp.	90-190	120-200	90-190	230	125-205
Yield Str., 1000 Psi.:					
Annealed	35-50	90-105	40	50	95
Hard. & Temp.	60-145	105-150	60-145	195	90-155
Mod. of Elast. in Ten., 1000 Psi.	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Elong. in 2 In., %:					
Annealed	25-35	15-20	30	25	20
Hard. & Temp.	15-30	15-20	12-25	8	15-20
Hardness, Bhn.:					
Annealed	155	235	155	195	260
Hard. & Temp.	180-390	250-410	180-390	500	260-415
Impact Str., Izod, Ft.-Lb.:					
Annealed	90	50	70	—	—
Hard. & Temp.	35-75	45-50	20-60	10	30-50
Fatigue Str. (End Limit), 1000 Psi.:					
Annealed	40	45	40	40	45
Creep Str., Load for 1% Elong. in 10,000 Hr., Psi. (Annealed)					
@ 1000 F	9200	Not	9200	Not	Not
@ 1300 F	1000	used	1000	used	used
THERMAL TREATMENT					
Annealing (Full) Temp., F	1500-1650	Impractical	1500-1650	1550-1650	Impractical
Hardening Temp., F	1700-1850	1800-1900	1700-1850	1800-1900	1800-1950
Tempering Temp., F	400-1400	400-1300	400-1400	300-700	400-1200
FABRICATING PROPERTIES					
Machinability	Fair	Poor	Good; 80% of screw stock	Fair	Poor
Weldability	Fair; small welds can be annealed	Poor	Poor	Fair	Poor
Forging Temp. (Initial), F	2000-2200	2100-2200	2100-2300	2000-2200	2100-2250
CORROSION RESISTANCE	As a group they have good resistance to weather and water; also good resistance to some chemicals.				
AVAILABLE FORMS	Plates, sheets, strip, bars, tube, rounds, structural and bar shapes, round and flat wire, and tubing.				
USES	Steam turbine blades, highly stressed parts	Springs, knive blades, tempered rules	Automatic screw machine use	Cutlery, surgical instruments, ball bearings, magnets	Used for high mech. properties

(Continued on page 95)

Another Cost-saving advantage of using

B&W MECHANICAL TUBING

WIDE

SIZE

RANGE

. . . means less time and material for making hollow parts

. . . BECAUSE a tube size is available to closely fit your individual requirements.

You have a *wide choice* of B&W MECHANICAL TUBING

TYPES	**Seamless (hot finished and cold drawn). Welded (from hot or cold rolled strip).**
GRADES	**Carbon, Alloy, and Stainless.**
SIZES	**Up to 8⅝" O.D. in full range of wall thicknesses.**
QUALITY	**Open-hearth and electric furnace steels, including aircraft and magnaflux qualities.**
CONDITION	**Unannealed, annealed, tempered, normalized, or otherwise heat-treated as required.**
SURFACE FINISHES	**As rolled, as drawn, as welded, bead removed, turned, scale-free, and polished.**

B&W SEAMLESS and WELDED TUBES

THE BABCOCK & WILCOX TUBE COMPANY
GENERAL OFFICES: BEAVER FALLS, PA.
PLANTS: BEAVER FALLS, PA. AND ALLIANCE, OHIO

BA-1518-M

Materials Engineering File Facts

NUMBER 179 (Continued)

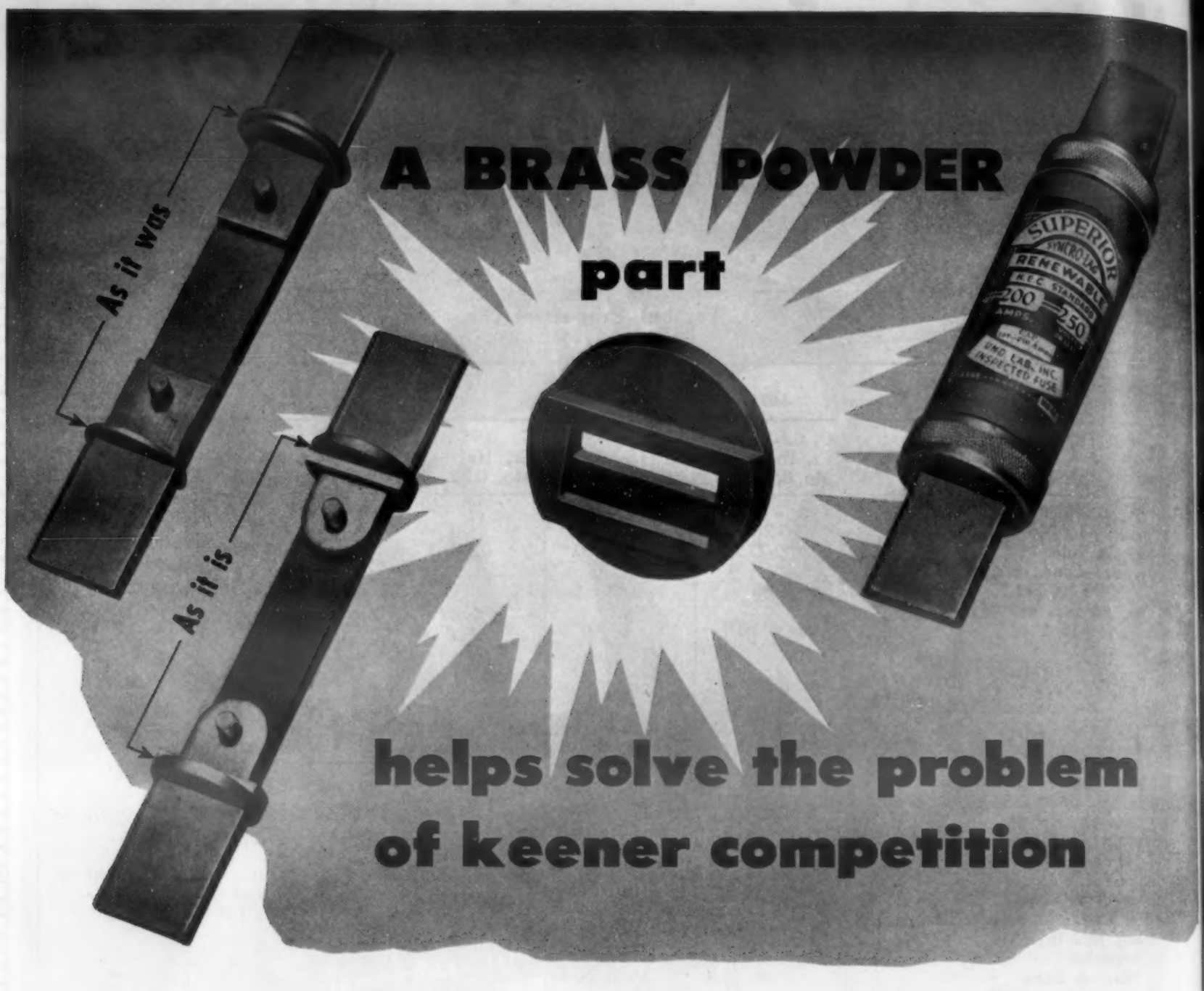
WROUGHT STAINLESS STEELS—MARTENSITIC TYPE

Typical Properties

Property \ Type	440 A	440 B	440 C	501	502
COMPOSITION, %	C, 0.60-0.75 Cr, 16-18 Mo, 0.75 max.	C, 0.75-0.95 Cr, 16-18 Mo, 0.75 max.	C, 0.95-1.20 Cr, 16-18 Mo, 0.75 max.	C, over 0.10 Cr, 4-6	C, 0.10 max. Cr, 4-6
PHYSICAL PROPERTIES					
Density, Lb./Cu. In.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2500-2750	2500-2750	2500-2750	2700-2800	2700-2800
Thermal Cond., Btu./Hr./Sq. Ft./Ft./°F, @ 212 F	14.0	14.0	14.0	21.2	21.2
Coef. of Exp. per °F:					
32 to 212 F	5.6×10^{-6}	5.6×10^{-6}	5.6×10^{-6}	6.2×10^{-6}	6.2×10^{-6}
32 to 1200 F				7.3×10^{-6}	7.3×10^{-6}
Sp. Ht., Btu./Lb./°F:					
32 to 212 F	0.11	0.11	0.11	0.11	0.11
Elect. Res., Microhms/Cm./Cm.^{2} (Room Temp.)	60	60	60	40	40
Magnetic Properties	Magnetic	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES					
Ten. Str., 1000 Psi.:					
Annealed	105	107	110	70	65-70
Hard. & Temp.	260	280	285	115-175	—
Yield Str., 1000 Psi.:					
Annealed	60	62	65	30	25-30
Hard. & Temp.	240	270	275	90-135	—
Mod. of Elast. in Ten., 1000 Psi.	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Elong. in 2 In., %:					
Annealed	20	18	14	28	30
Hard. & Temp.	5	3	2	15-20	—
Hardness, Bhn.:					
Annealed	215	220	230	160	150
Hard. & Temp.	510	555	580	240-370	—
Impact Str., Izod, Ft.-Lb.:					
Annealed	2	2	2	—	85
Hard. & Temp.	4	3	2	—	—
Fatigue Str. (End Limit), 1000 Psi.:					
Annealed	40	40	40	35	35
Creep Str., Load for 1% Elong. in 10,000 Hr., Psi. (Annealed)					
@ 1000 F	Not used	Not used	Not used	9500	9500
@ 1300 F				800	800
THERMAL TREATMENT					
Annealing (Full) Temp., F	1550-1650	1550-1650	1550-1650	1525-1600	1525-1600
Hardening Temp., F	1850-1950	1850-1950	1850-1950	1600-1700	Generally used in annealed condition only
Tempering Temp., F	300-800	300-800	300-800	400-1400	
FABRICATING PROPERTIES					
Machinability	Fair	Fair	Fair	—	—
Weldability	Not recommended generally	Not recommended generally	Not recommended	—	—
Forging Temp. (Initial), F	1900-2200	1900-2150	1900-2100	—	—
CORROSION RESISTANCE	As a group they have good resistance to weather and water; also good resistance to some chemicals.				
AVAILABLE FORMS	Plates, sheets, strip, bars, tube rounds, structural and bar shapes, round and flat wire, and tubing.				
USES	Instruments, cutlery, valves			Used for its heat resistance and good mech. properties at elev. temp.	

References

Steel Products Manual, Section 24, American Iron & Steel Institute
Metals Handbook, 1948 Edition
Metals and Alloys Data Book



It was a good fuse to start with—but in keeping with the times, production efficiency and sales appeal had to be stepped up in an increasingly critical market.

Here is what a brass powder part did.

1. Simplified assembly—only one interchangeable part instead of two.
2. Improved appearance—helped make a neater, trimmer looking fuse.
3. Reduced overall production troubles—powder metallurgy was the only practical method of producing a part sufficiently flat and to reasonable tolerances.

HORSE HEAD PRODUCTS

SEND FOR FREE COPY OF NEW BOOKLET
"Applications and Properties of Nonferrous Powder Parts"

PRESENTING:

1. 14 case histories of cost savings
2. Properties of the commonly used Brass Powders.

THE NEW JERSEY ZINC COMPANY

160 Front Street, New York 7, N. Y. . . . . 221 N. LaSalle Street, Chicago 1, Ill.

New Materials and Equipment

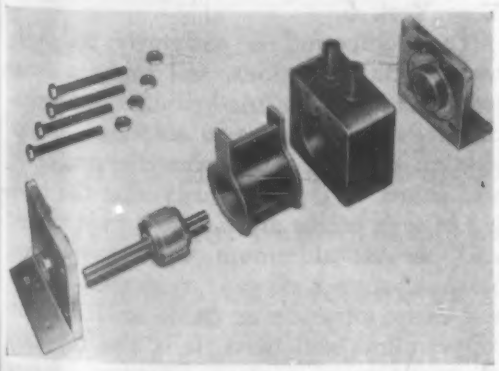
Special Lining Makes New Pump Suitable for Corrosive Fluids

A noncorrosive Flex-i-Liner pump in which the transferred liquid or gas never touches any of the metal parts has been developed by the *Vanton Pump Corp.*, Empire State Bldg., New York 1. The self-priming, positive displacement pump is particularly suitable for handling corrosive liquids such as acids, alkalis, industrial alcohols, as well as many corrosive gases.

The construction of the pump is such that the fluid flows on the outside of the Flex-i-Liner and on the inside of the body block. The Flex-i-Liner material can be specified in either a pure gum rubber or a synthetic, depending on the particular application, while the body block can be obtained in plastic or hard rubber. An eccentric rotor mounted on a ball bearing rides inside and activates the Flex-i-Liner. The "squeegee" action thus created is the basis of the pump operation.

The possibility of external leakage and contamination by oil or grease is avoided by eliminating glands or stuffing boxes from the design. Simplicity is served by the absence of check valves of any sort. Maintenance is claimed to be a negligible factor, with infrequent replacement of the Flex-i-Liner the only pump service necessary. The replacement requires no removal of pipe lines or attached equipment.

The four models available at the present time have capacities of 20, 60, 120, and 180 gal. per hr.



Disassembly view of the compact noncorrosive pump, designed by Vanton Pump Corp.

Corrosion Resistance Achieved by New Plastic Coating System

A selective coating system, known as Cyclon Series WPS, designed for the protection of all types of metals that are subjected to extreme corrosive conditions, has been announced by *Murray Products, Inc.*, 12400 Crossburn Ave., Cleveland 11, sales division of Poly-Cyclo Products Co.

The WPS series, as applied, includes a primer, tie-coat, and top coat, all formulated essentially from basic vinyl plastic resins. Adhesion to the metallic surface is secured by chemical inner-reaction of the primer with the metal surface, providing an integral bond. Thus, mechanical roughening of the metal surface is not necessary. The corrosion-inhibiting pigments of the primer develop a tough, impermeable film said to prevent underfilm metal deterioration. High bond strength is reported for zinc, lead, cadmium, aluminum, nickel, copper, stainless steel, galvanized metals, and magnesium.

The tie-coat in itself has good chemical resistance and, when used over the primer, is said to be applicable for general maintenance where atmospheric corrosion or water immersion is a problem. The top coat is designed to be unaffected by acids, akalis, salts, petroleum products, alcohols, water and many other reagents. It is said to have flexibility over a wide temperature range and good dielectric properties, as well as toughness and permanency. The three resin coats are claimed to form a homogeneous, non-laminating film as a result of blending of the coats after application.

● A twin oxyacetylene hose in which two lengths, one red and the other green, are joined by a thin strip of rubber has been announced by the *B. F. Goodrich Co.*, Akron, Ohio. The hose will be marketed under the brand name Duo-Weld. The strip also allows the hose to be separated into single lengths, when that is desirable, without tearing into the cover of either length. The hose is being made in 50-, 25- and 12½-ft. lengths. Each length is separated approximately 18 in. from each end and secured with a metal ferrule at the separation point.

New Materials and Equipment
(CONTINUED)

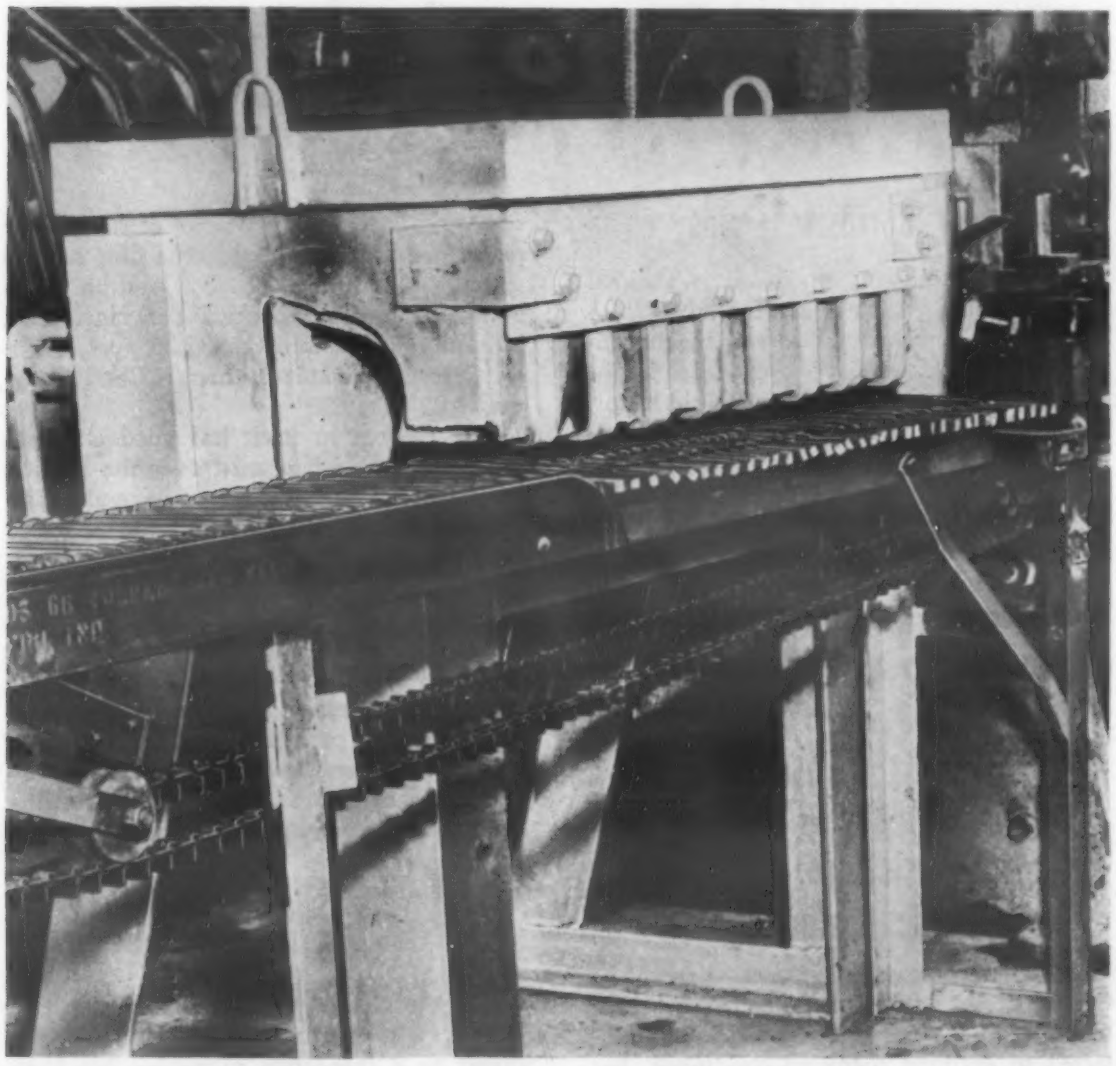
Production Increased by End Heating Furnace of New Design

A new end heating furnace, designed for high-speed heating and low scale formation, has been introduced by *Gas Appliance Service, Inc.,* Chicago.

Special features of the Roto-Flame furnace include high manifold pressures, a small combustion chamber, and a curved refractory section which keeps the flame on the work. The furnace is adapted to forging, swaging, upsetting, threading, hardening and annealing. Scale formation is limited as the ends of the pieces being heated are entirely enclosed in flame. The new furnace is claimed to be as much as two or three times faster than conventional furnaces.

In operation, the curved refractory section becomes completely incandescent, with the radiant heat from this surface further increasing heat input. The refractory shape keeps the operator cooler and permits use of a conveyor. The unit is fired with a relatively large number of small, high-pressure burners.

The Roto-Flame furnace is available in several different sizes and lengths to meet most production requirements, and can be furnished with or without a conveyor.



This end heating furnace, manufactured by the Gas Appliance Service, Inc., keeps the heat on the work and away from the operator.

New Coating Designed for Metal Stampings

A new plastic coating designed especially for metal stampings has been introduced by the *Black-Ox Chemical Co.,* Newark, N. J. With the use of a new transparent and durable plastic, called Krylon, it is claimed that several steps that have been used in other coating processes can be eliminated.

This plastic coating is said to show no tearing or tendency to pull off when placed on the agitating conveyor after dipping. Stampings can be handled in 2 min. and the coating hardens in 5 min.

The coating will undergo a temperature range of from –70 to 225 F without cracking or peeling. The plastic film is also resistant to dilute acids, alcohols and alkali, chemical fumes, grease, oil and water.

The finish air dries and can be applied by several different methods such as spraying and brushing, in addition to dipping.

Extruded Kennametal Available in Solid Rounds, Tubes, Flats

Kennametal Inc., Latrobe, Pa., is now manufacturing extruded Kennametal of four different compositions in three standard shapes—solid rounds, tubes, and flats. Special shapes can also be made on order.

The standard shapes are available in lengths up to 10 in.; solid rounds in diameters ranging from 1/32 through ½ in.; tubes in O.D.'s from 1/16 through ½ in. with I.D. specified by customer; flats in thicknesses of 1/16 or ⅛ in. and widths ranging from ¼ through ½ in. Grades in which these shapes are available are KE5, KE7, K138 and K138A.

Solid Kennametal rounds are used as feed fingers, rollers, laps, scribers, engraving tool points, thread checking wires, punches, and wear pins. The tubes are suitable as wire and thread guides, orifices, nozzles and punch and die parts. Flats have been used as centerless grinding rests, wear strips, inserts for wood-working tools, and for other purposes.

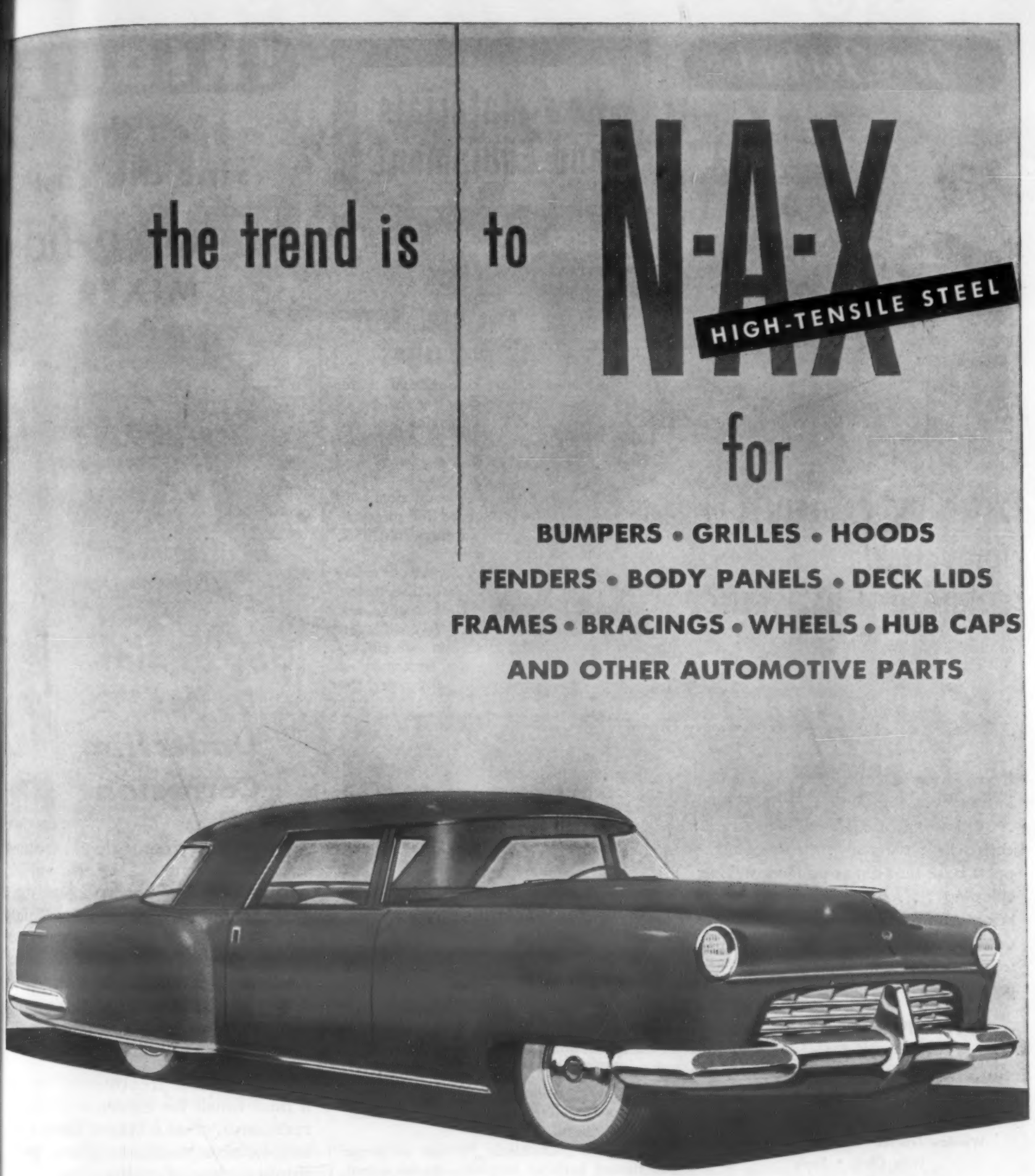
New Compound Useful with Acid Pickling Solutions

A new material, Oakite Composition No. 38, which is said to produce a dense foam on acid pickling solutions and effectively seals in evolved gases, has been introduced by *Oakite Products, Inc.,* 132H Thames St., New York 6.

The compound is extremely stable in highly acidic solutions, and forms a dense foam blanket on nitric-hydrofluoric, hydrochloric, and sulfuric acid solutions to provide an efficient seal against the escape of acid fumes. It is said to minimize the fuming of such bright dips as nitric-hydrofluoric acid on cast aluminum, nitric-sulfuric on brass and copper alloys at room temperature, and nitric-sulfuric-zinc oxide at 180 F on copper alloys and brass. It is also reported effectual for use in plants where acid fumes escaping into the air tend to rust exposed metal surfaces.

the trend is to N-A-X HIGH-TENSILE STEEL for

BUMPERS • GRILLES • HOODS
FENDERS • BODY PANELS • DECK LIDS
FRAMES • BRACINGS • WHEELS • HUB CAPS
AND OTHER AUTOMOTIVE PARTS



for **High Strength • Finer Grain Structure • Good Formability • Great Impact-Toughness • Excellent Weldability**
High Corrosion-Resistance • High Fatigue-Resistance

N-A-X HIGH-TENSILE MEETS ALL REQUIREMENTS OF S.A.E. 950

Specify N-A-X HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
Unit of National Steel Corporation

Free Folder!

--tells how to finish
ZINC OR CADMIUM
for better
CORROSION RESISTANCE
...PAINT BASE

Eye Appeal

If your product uses zinc or cadmium in any form, find out now about Iridite . . . the chemical dip finishes that boost corrosion resistance . . . provide a paint base that defies peeling, flaking, chipping . . . brighten zinc, keeps it bright and free from stains. Write for details today . . . or better still, send samples of your product for FREE processing.

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are used on--

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Wire Cloth • Tools
Lamp Fixtures • Fuel Pumps
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Zinc Coated Sheet • Hinges, Screws, Bolts
Camera Parts • Plumbing Fixtures
Wall Panels • Refrigerator Parts
Wire Products • Instrument Parts
Electrical Equipment

ALLIED RESEARCH
PRODUCTS, INC.
4004 EAST MONUMENT STREET
BALTIMORE 5, MD.

New Materials and Equipment

New Test Head Developed for Metals Comparator

More extensive application and wider utility is said to be provided for the metals comparator by a new comparator test head which has been announced by the *Special Products Div., of the General Electric Co.*, Schenectady 5, N. Y. For use on flat surfaces, particularly of large equipment, the new test head was developed for those instances in which the conventional test unit, the test coil, is inapplicable.

By comparing ferrous or nonferrous metal parts with a known standard, the metals comparator provides a non-destructive test of the quality of the parts. It enables an operator to maintain control on such characteristics as composition, heat treatment, or hardness. Besides being a quality tester, the

New test head being used to test the wearing surface on a machine-tool bed.

instrument provides a means of decreasing scrap losses due to mixed material or incorrect processing.

Designed particularly for use on large specimens such as forgings, machine tool beds, and other parts which cannot be inserted in the test coil, the new test head has greatly extended the usefulness of the comparator. The contact face of the new head consists of a ring separated from a concentric core by an air gap, thereby forming a radial magnetic path across which the test piece is placed. It is 3 in. long, and it can be supplied in various face diameters, depending upon the application.

The metals comparator is basically an impedance comparator. The impedance of a test unit will vary with the electrical and magnetic properties of the specimen being tested. Through the use of standard or reference specimens, changes in the chemical and physical properties are correlated with the electrical and magnetic properties.

IRIDITE
on the
zinc die cast
KitchenAid
MIXER

Grips Paint--
Defies
Underfilm
Corrosion

Applied by a simple dip . . . without electric current . . . Iridite quickly forms a tough, corrosion-resistant coating on *any* zinc or cadmium surface. This Iridite film provides superior paint adherence by effectively sealing the metal from direct contact with the paint, yet grips the paint securely to block chipping, flaking, peeling.

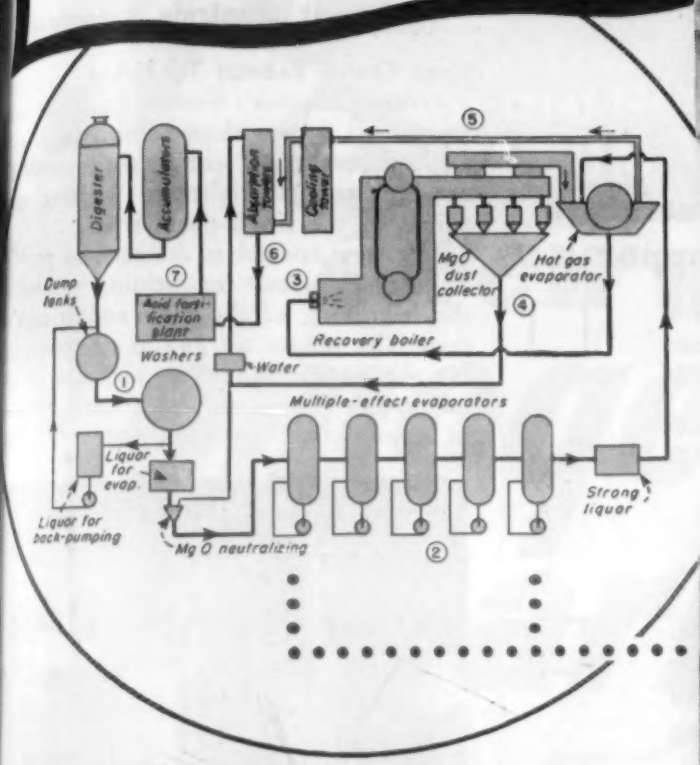
Use the Iridite treatments, too, as a final finish for extreme corrosion resistance, or as a bright finish that keeps zinc or cadmium plated parts shining, clear of stains.

FREE to users of zinc or cadmium in any form—literature and samples of Iridite. Test it yourself! Or, if you prefer, send samples of your products for free processing.

ALLIED RESEARCH
PRODUCTS, INC.
4004 EAST MONUMENT STREET
BALTIMORE 5, MD.

West Coast Licensee—
L. H. Butcher Co., Los Angeles 23, California

Sulphite waste recovery system
COMBATS CORROSION



Flow chart for this new system at Weyerhaeuser Timber Company's Longview, Washington, pulp mill.

All vessels and vapor lines in this evaporator are Lukens 20% Stainless-Clad Steel, built by General American Transportation Corp.

. . . with Stainless-Clad Steel

Recovery of sulphite-process chemicals, elimination of stream pollution, steam for process and power generation—these are the advantages of this new process. It employs magnesium oxide as the base for the cooking liquor, instead of the usual calcium oxide.

Lukens Stainless-Clad Steel, used in the quintuple effect evaporator pictured above, combats corrosion in case liquors and vapors become acid in character. Because stainless steel is only 20% of total plate thickness, the economies gained by using clad steel made it feasible to proportion vapor lines and vapor bodies generously to take care of considerable overloads.

Should your conditions require the protection offered by nickel, Inconel or Monel, Lukens makes a complete line—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels. In each, the cladding is permanently bonded to its backing plate. All are available in the extra-smooth sodium hydride finish.

Send for Bulletin 470, giving information on clad steels in the Pulp and Paper Industry, or Bulletin 449, a general bulletin on Lukens Clad Steels. Lukens Steel Company, 419 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS
Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

HOW to SAVE DOLLARS with BERYLLIUM-COPPER

Here is an opportunity to improve your product and—at the same time—cut costs. Valuable guides for the most economical use of age-hardening beryllium-copper, based on years of research and practical experience, are yours for the asking. Write TODAY for any or all of the following reprints.

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Case histories of successful designs where specific properties of beryllium-copper were used for best performance at lowest cost. ☐

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Technical data covering elastic strength, resistance to corrosion and fatigue, conductivity and other properties which make beryllium-copper ideally suited for spring design. ☐

Production of Metal Diaphragms

Helpful facts about beryllium-copper diaphragm design together with recommended tooling, heat-treating and testing procedures. ☐

How to Machine Beryllium-Copper

An up-to-date report summarizing current machining practice including proper tools, feeds, speeds and cutting fluids. ☐

How to Heat Treat Beryllium-Copper

Suggested techniques for low-cost heat-treating to meet specific property requirements without expensive equipment. ☐

In addition to the above literature, we have other data available. Or if you have a design problem, send us full information with a drawing or sample of the part.

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The **BERYLLIUM CORPORATION**

Dept. 6, Reading 3, Pa.

New Materials and Equipment

Recent Developments in Welding Equipment, Controls Announced

Slope Control Reduces Tip Pickup

General Electric's Control Divisions have announced a new slope control for use as an accessory with either synchronous or non-synchronous resistance welding machines of the single-phase type.

The new control is designed to provide a gradual increase in welding current at the beginning of the weld and is said to materially reduce tip pickup on spot welding aluminum, magnesium and their alloys. Laboratory tests with this control resulted in obtaining 20 times the number of spot

General Electric's new slope control provides gradual increase in current at the beginning of the weld.

welds on 0.064-in. 24 ST Alclad before sticking occurred, than were obtained without the control.

This control is also claimed to be desirable for welding heavy gage steel and for projection welding, as it minimizes expulsion.

Weld Energy Checked by Comparator

A new weld energy comparator, designed to check weld energy consistency on applications where high-quality welds are essential, has been announced by *Westinghouse Electric Corp.*, Box 868, Pittsburgh 30.

The comparator gives a visual and/or audible signal and can be used with any Westinghouse single-phase spotwelding control. The unit can be interlocked with the welding machine to lock out further welding in case the weld energy is not within pre-set limits.

AN IMPORTANT MESSAGE TO METAL WORKERS INTERESTED IN:

SPINNING, BLANKING, STAMPING, MACHINING, ETC.

1. FORM THIN SECTION PARTS OF **LOW CARBON STEEL**
2. HEAT TREAT FORMED PARTS TO *INCREASE* CARBON TO A **MEDIUM OR HIGH CARBON STEEL**

A *New* HEAT TREATMENT

Homogeneous Carburization

Broadens the Scope of Production of Small Metal Parts

In homogeneous carburization the carbon content is built up throughout the entire thickness of the steel. The carbon potential of the prepared gas atmosphere is adjusted equal to the carbon desired in the steel. Then the low carbon steel is heated in this atmosphere where the carbon content gradually raises until the equilibrium is established between the atmosphere and the steel being treated.

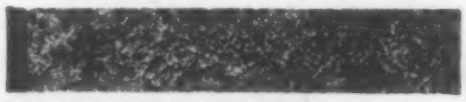
RX Gas Atmosphere

A 'Surface' RX Gas atmosphere is used for the process. 'Surface' RX Gas generators have been used extensively in industry for gas carburizing, dry cyaniding, carbon restoration, and clean hardening. They have proved most satisfactory in operation since they maintain an output of prepared gas atmosphere of constant analysis with a minimum of adjustment and maintenance.

THE PROCESS:

Homogeneous carburization permits the transformation of a low carbon steel into a medium or high carbon steel, in parts of thin section, after fabrication, and oftimes during the final step of heating for hardening.

BEFORE: Fabrication of low carbon steel (1/16" section) before heat treatment. 100X—nital etch.



AFTER: 1/16" section homogeneous carburized throughout at 1700°F. in RX Gas atmosphere with a 0.60% carbon potential. Oil quenched. 100X—nital etch.

Continuous or Batch Type Furnaces

Either continuous or batch type furnaces can be used that have a heating chamber suitable for complete exclusion of both air and flue gas. Modern 'Surface' radiant tube heated furnaces, which have the necessary safeguards for good atmosphere control, are most applicable to this new process.

'Surface' Research and Development

The principles of carbon balance which have been so well applied to 'Surface' gas carburizing to permit control of surface carbon concentration, regardless of case depths, have been just as satisfactory adapted to homogeneous carburization at any desired carbon level from low and medium carbon to 1.00% carbon and higher if required.

WRITE FOR COMPLETE DETAILS...
NO OBLIGATION

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

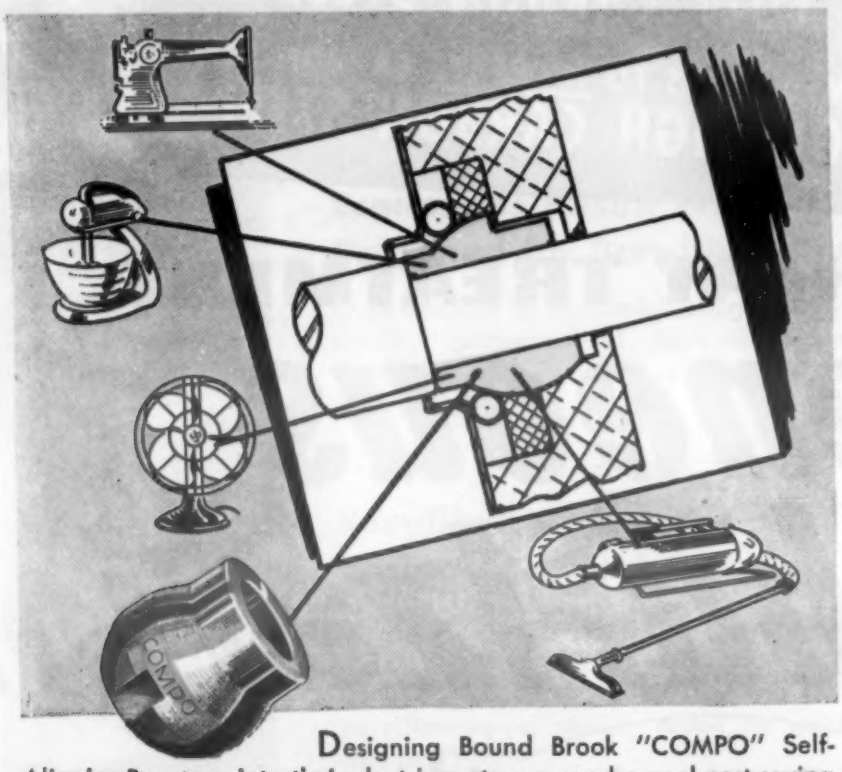
'Surface' INDUSTRIAL FURNACES

"COMPO" OIL-RETAINING POROUS BRONZE BEARINGS

Why Well-Known Electrical Appliance Manufacturers* Demand "COMPO"

FOR SELF-ALIGNING MOTOR BEARINGS

*NAMES ON REQUEST.



Designing Bound Brook "COMPO" Self-Aligning Bearings into their electric motors proved a real cost-saving way to insure motor-shaft alignment, less wear on parts, and smoother, quieter, performance. It also meant:

TO MANUFACTURERS • Simplification of design; quicker, easier assembly • Elimination of oil cups, machining, drilling, tapping and grooving of the housing.

TO USERS • No periodic lubrication, quiet, trouble-free performance —under both continuous and intermittent operation.

"COMPO" Porous Bronze Bearings are made from pure metal powders, die-formed to shape, alloyed at high temperatures, finished to exact dimensions, and vacuum-impregnated with lubricant. Self-lubricating qualities make them ideal for use in inaccessible spots. The lubricant is sealed in, free from dirt, and an even lubricating film is always present.

Thousands of "COMPO" Bearing sizes can be made from existing dies; hundreds of sizes in stock for prompt shipment. Mail the coupon below, to get our Stock List or arrange a conference with one of our engineers. *We've saved time and costs for others; we can do the same for you.*

Many other types of "COMPO" Bearings and "COMPO" structural parts have been designed into appliances and other types of equipment and machines at equal savings and with equal performance benefits.

BOUND BROOK OIL-LESS BEARING COMPANY

BEARINGS • BUSHINGS "COMPO" "POWDERON" BOUND BROOK **WASHERS • PARTS**

BOUND BROOK, N. J. *ESTABLISHED 1883*

Bound Brook Oil-Less Bearing Co.
Bound Brook, N. J. MM 9-49

☐ I would like to talk to one of your engineers about_____

☐ Please send me a copy of your "COMPO" Bearing Stock List.

Name_____ Title_____

Company_____

Street_____ City_____ State_____

New Materials and Equipment

Arc Welder Suitable for Pipeline Jobs

Production of a new heavy-duty arc welder, known as the Wilson 36A Yellow Jacket, has been announced by *Air Reduction Sales Co.*, 60 E. 42 St., New York 17. Built in 300- and 400-amp. sizes, the Yellow Jacket is said to be particularly suitable for pipeline work, construction jobs, or any work where ruggedness and durability are important.

The new arc welder is a direct current, 40-v., NEMA-approved variable voltage generator. Simplified control of current output is afforded by a sturdy hand-wheel mounted on the control cabinet. Close calibration of the current dial eliminates the need for meters.

Electrode Designed for Alloy Steels

A new corrosion-resistant a.c.-d.c. electrode especially suitable for welding special type high chromium-nickel steels has been announced by *All-State Welding Alloys Co., Inc.*, 273 Ferris Ave., White Plains, N. Y.

The electrode, known as All-State No. 299, is designed for the welding of vanadium-molybdenum spring steels, nickel-clad steels, medium-carbon steels and air-hardenable steels. Tensile strength of 110,000 to 120,000 psi., work-hardenable to 180,000 psi., is reported for the electrode material.

Weld Nut Centered by Collar

A new type Gripco Pilot projection weld nut, designed for easy, quick positioning or centering at the spot where it is to be welded to the metal, has been announced by the *Grip Nut Co.*, 306-Y S. Michigan, Chicago 4.

A circular collar with a diameter slightly less than the bolt hole is provided on the weld nut. Inserted into the bolt hole, this collar automatically centers the nut accurately, ready for the welding operation.

Primer Designed for Aluminum Has Good Abrasion Resistance

A new metal primer, Di-Noc N33, designed especially for aluminum, has been announced by the *Di-Noc Co.*, Cleveland.

The new primer is said to have (1) excellent adhesion to aluminum without special preparation, and (2) excellent abrasion resistant characteristics. After application, Di-Nox N33 readily accepts an over coat of most regular finishes—lacquer, enamel, etc. It can be air dried, force dried or baked.

Di-Nox N33 can be adapted to steel and other metals.

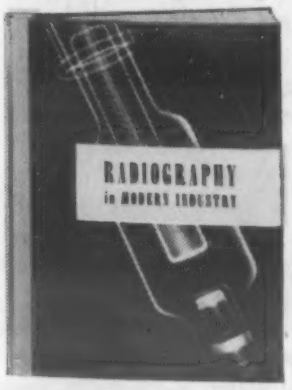
What's the right X-Ray film?

ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE K

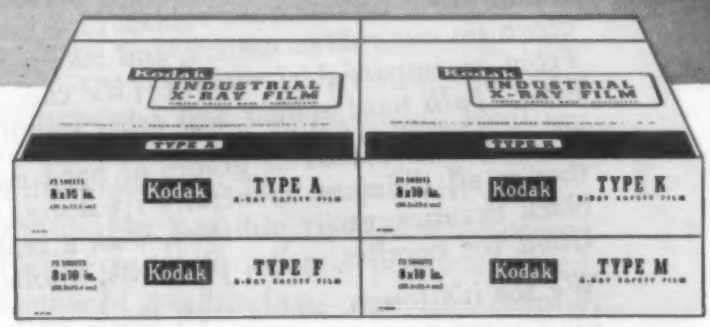
The wall of the tank was thick—the kilovoltage available was low. And the customer was impatient for delivery. So the radiographer did this job with Kodak Industrial X-ray Film, Type K.

This film, in contact with lead foil screens, has sufficiently high speed to allow reasonable exposure with equipment of moderate power. The good definition so obtained is added assurance that significant weld irregularities will not be missed.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price $3.00.



A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film. They furnish the means to check welds efficiently and thus extend the use of the welding process.

Type K has medium contrast with high speed. For gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without calcium tungstate screens.

Type F provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead screens.

Type M provides maximum radiographic sensitivity, high contrast, and exceptional detail under direct exposure or with lead foil screens. It has extra fine grain and the speed is adequate for examination of light alloys at moderate kilovoltage and for much million-volt radiography.

Type A offers high contrast with about three times the speed of Type M, but with slightly more graininess. Used direct or with lead foil screens for study of light alloys at low voltages, and of heavy steel parts at 1000 kv.

EASTMAN KODAK COMPANY
X-ray Division · Rochester 4, N. Y.

"Kodak" is a trade-mark

Radiography...

another important function of photography

Kodak

ACE

John R. MacKay tells:

HOW TO RECOGNIZE A JOB FOR HARD RUBBER

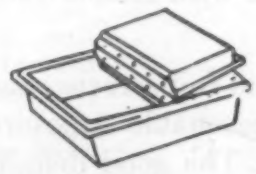
How can a man think straight about materials when so many new ones are always popping up. Now take hard rubber, for instance.

It's been all around us for nearly a century. Let's clamp down on our hard rubber pipe bits, ease ourselves down on our rubber casters, and take a good look. From an impartial viewpoint. (*We* can, because Ace molds *both* hard rubber and other important plastics).

First, we see dozens of grades of hard rubber, and they're all different. Generally speaking, they're black beauties, easily polished, with a real nice feel. *Good* for handles, grips, pipe bits, knobs, combs, etc.

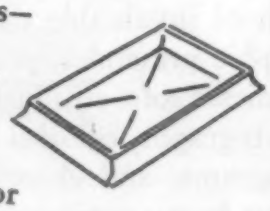
We see it's tough, stable stuff that's well nigh impervious to water and 'most all known chemicals. (Except mineral oils and organic solvents— but Ace *synthetics* take care of them.) Its resistance to water is topped only by Ace polyethylene.

Tensile strength of hard rubber is up with the best plastics—up to 9,700 psi. Coefficient of expansion is very low—good for refrigerator parts. For the hot spots, we can give you compounds that won't distort up to 250° F., but don't count on more than 150° from any general purpose mix.



You probably know all about the top-notch electrical properties of hard rubber. But did you know its wear resistance is so good it's often used in bearings? So tough it's used in bowling balls.

Add it all up—Ace hard rubber is good for a lot of things—water meter parts, magneto parts, foot tubs, vinegar dumpers, fountain pen parts, sparges (if you know what *they* are) and chemical piping. It's probably natural for a lot of things you make, too.



Want to know more? Just tell me your problems or ask for a copy of our new Hard Rubber and Plastics Handbook.

ACE

HARD RUBBER and OTHER IMPORTANT PLASTICS

AMERICAN HARD RUBBER COMPANY

Since 1851

11 MERCER STREET • NEW YORK 13, N. Y.

New Materials and Equipment

High Strength Ceramics Are Useful in Industry

High strength industrial ceramic materials have recently been introduced by the *Coors Porcelain Co.*, Golden, Colo., which should prove valuable to many industries. Their properties suit them for mechanical parts of equipment where corrosion, wear, friction or high temperature affect the durability of metals or other materials, or for electrical application where superior dielectric properties are required.

High resistance to heat makes the materials better than commonly-used metals for many parts; resistance to corrosion and friction makes them valuable as high pressure valve parts, bearings, etc. High strength and resistance to abrasion and corrosion of the ceramics makes them efficient for various designs such as grinding balls, nozzles, extrusion dies, surface plates, plug and ring gages, parts of pumps, parts of steam, gas and water valves, bearings, high frequency insulators, etc.

Typical parts made from the new high strength ceramics.

The ceramic parts are made with close tolerances and fine finishes in various types for specific services, depending upon the operation requirements. Physical properties vary according to the type. AI-200 Alumina, for example, has a tensile strength of 25,000 psi., compressive strength of 290,000 psi., a coefficient of expansion about 50% that of steel, a specific gravity of 3.63, and a hardness comparable to natural sapphire.

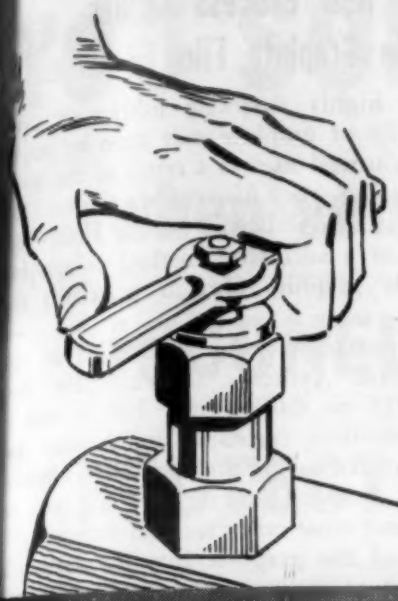
Parts made of these ceramics are machined before final hardening to close tolerances, although extreme skill must be used in firing because shrinkage takes place in this operation. Shrinkage is carefully controlled and parts are ground to the finished dimension after firing. The material must be ground with diamond wheels, since it is almost as hard as diamonds—has a hardness about equal to natural sapphire.

These high strength aluminum oxide ceramics were developed commercially by

TURN OFF HIGH MACHINING COSTS...

with Free-Machining

Enduro Stainless Steel



The uniformly high machinability of Free-Machining ENDURO Stainless Steel does it for you . . . fast. Yet, that is only one of many qualities which enable you to keep product cost down and product quality up.

In these acid valve parts, for example, close tolerances, accuracy of section, uniform soundness and fine surface finish, resulting from the advanced Union Drawn process of cold drawing, all contribute toward production economy. And ENDURO's unsurpassed corrosion-resistance affords pre-determined assurance of trouble-free valve life, despite rigorous, corrosive operating conditions.

Whenever stainless steel enters your machined parts picture, remember that it pays to specify Free-Machining ENDURO Cold Finished Bars. They, as well as hot rolled bars and wire, are available for immediate delivery. Write today for specific information and prices.

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

GENERAL OFFICES • CLEVELAND 1, OHIO

Export Department: Chrysler Bldg., New York 17, New York

YOU, TOO, CAN BE AN EXPERT ON "PROFITS"

Wouldn't you like to have clear, concise answers to the many questions you may be asked on this all-important subject? We have them for you—in an interesting, colorful booklet written by Phelps Adams of The New York Sun. Write us for a copy.

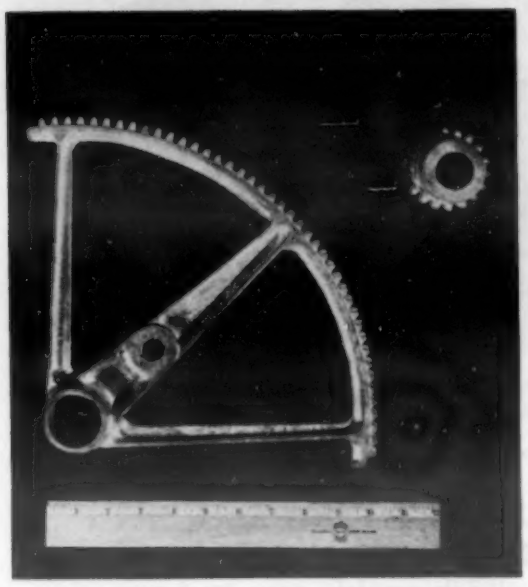
Republic ENDURO FREE-MACHINING STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

SAVE TIME
SAVE MACHINING

. . . with plaster mold castings



This gear sector and pinion set (shown in "as cast" condition) saves over four dollars per set compared with the parts it replaced. Cast in Atlantalloy No. 31, high tensile manganese bronze, these castings have high strength, great uniformity, and need only reaming and threading for completion. Teeth are cast to working tolerances with smooth finish and are ready for use.

"ATLANTICASTINGS" are available in many copper base and aluminum alloys. Tolerances to plus or minus .005" reduce or eliminate machine work. Low-cost die patterns are permanent and can be modified readily and at small expense. Pattern costs are easily justified when limited quantities are to be run, and patterns can be produced in a short period of time.

We invite your inquiries on parts which are problems to you. Catalog No. 4 will be sent at your request.

ATLANTIC CASTING & ENGINEERING CORP.
721 Bloomfield Avenue, Clifton 4, N. J.
Established 1937

Non-ferrous Castings from Plaster Molds

New Materials and Equipment

spark plug manufacturers for airplane engine spark plug insulators during the war. This is still an important use of the material.

Large Sizes of Tubing Handled by Manually-Operated Bender

The *Parker Appliance Co.*, Cleveland, has developed a new manually-operated production tube bender for handling of large sizes of tubing up to 3-in. dia.

The new bender, Model 848, accommodates thin or heavy wall copper and aluminum alloy tubing, and light- or medium-gage annealed steel tube. It is intended to complement the Parker G824 bender having a capacity of 1½-in. O.D. tube, and uses the same accessory equipment.

New Process Applies Stable Graphite Film to Surfaces

The highly desirable lubrication characteristics of graphite may soon be put to new industrial uses as a result of the development by the *Electrofilm Corp.*, 7116 Laurel Canyon Blvd., North Hollywood, Calif., of a successful method of applying a stable graphite film to practically any surface.

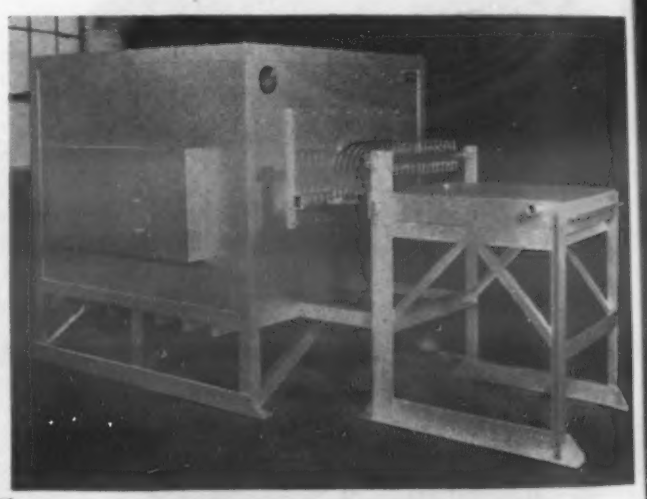
The graphite film, as applied by the Electrofilm process, is extremely thin (0.00015 to 0.0005 in.) but is said to have excellent resistance to abrasion and exceptional bearing strength. The adhesion to the intended surface is high, and on metal and most other surfaces sufficient diffusion of the graphite into the surface is obtained to insure presence of a graphite surface even when the external coating has apparently been removed.

The coating is stable, providing the intended surface characteristics over a temperature range from −120 F to as high as 2000 F in some cases. The graphite film is unaffected by exposure to solvents and weather.

Application is by spray or dip, following normal surface preparation. Generally, no plating is required, although the film can be applied over plated parts. The new process has been used successfully on metal, plastics, rubber and ceramics.

Harper

HIGH TEMPERATURE ELECTRIC FURNACES



HOU-30240-NT-28 Wire Annealing Furnace

For

ASSAYING
ANNEALING
BATCH MELTING
BRAZING
CERAMICS
HEAT TREATING
RESEARCH
SINTERING
SPECIAL APPLICATIONS

BRIGHT ANNEALING of stainless steel wire can be quickly and easily accomplished in a Harper Electric Annealing Furnace in which accurate temperature and special atmosphere control assures an evenly fired product.

The above photograph shows a special Harper Furnace built to meet our customer's requirements for annealing 30 strands of stainless steel wire in hydrogen.

Write for data on Harper Annealing Furnaces and if you have a specific research or production problem send us your requirements and our engineers will be glad to design and quote on special equipment for you.

HARPER ELECTRIC FURNACE CORPORATION
1461 BUFFALO AVENUE, NIAGARA FALLS, N. Y. • Representatives in Principal Cities

YOU SOLVE 4 PROBLEMS

when you switch to

INCONEL* THERMOCOUPLE PROTECTION TUBES

HIGH TEMPERATURES!

Inconel is ***thermally durable.*** Hundreds of high-temperature applications in many fields have demonstrated the heat resistance of this 80% Nickel—14% Chromium alloy. You can use Inconel thermocouple protection tubes up to 2200° F. in sulfur-free atmospheres.

And at ***any*** temperature, you'll find the thinner walls of close-grained Inconel tubes a big help where you need ***quick, accurate response*** to temperature changes.

CORROSION!

Inconel is ***corrosion-resisting.*** Because Inconel combines excellent thermal endurance with all-'round corrosion resistance, you can use Inconel protection tubes to guard thermocouples against chemical attack by carburizing vapors and gases . . . nitriding atmospheres . . . hydrogen-nitrogen atmospheres . . . fused salt baths.

The greater impermeability of ***seamless, drawn*** Inconel tubes also means better protection of thermocouples from harmful gases.

MECHANICAL SHOCK!

Inconel is ***strong*** and ***tough.*** And, it has good strength and toughness at high temperatures. In many jobs *(for example, forging furnaces)*, thermocouple protection tubes have to take bumps and jolts during charging and discharging. These are the jobs where use of Inconel pays an ***extra*** dividend. As a matter of fact, its high hot-strength frequently makes Inconel the choice even where excessive corrosion or high temperature is not a problem.

REDUCING AND OXIDIZING ATMOSPHERES!

Inconel has met the problem created by increased use of ***reducing*** atmospheres in bright annealing, nitriding, oxide reduction, and similar operations. Inconel gives long service in these processes because it resists the embrittling effects of hydrogen-nitrogen atmospheres.

Or if your operation is carried out in an ***oxidizing*** atmosphere, you can count on Inconel tubes here, too. For Inconel resists scaling . . . ***even at high heat.***

Prevent operating interruptions caused by thermocouple protection tubes that can't "take it."

Standardize on Inconel tubes wherever possible! For most jobs their longer life makes the cost ***actually less*** than the tubes you are now using.

Seamless, drawn Inconel protection tubes, with one end closed and the other end threaded, are available in standard IPS diameters. ***Your regular supplier or instrument manufacturer can furnish any size or length with either standard or extra-heavy wall thickness.***

*Reg. U. S. Pat. Off.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York 5, N. Y.

INCONEL—for long life at high temperatures

(80 NICKEL-14 CHROMIUM)

Superior

ROUND & SHAPED TUBING

(.010" to 5/8" O.D. Max.)

Available in:

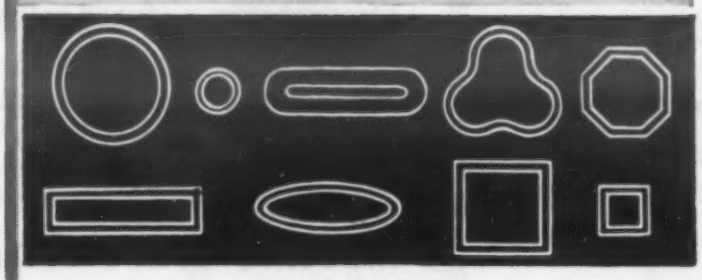
Carbon Steels:
AISI—MT C-1008, 1010, 1015, 1020, 1025, 1035, 1075, 1095

Alloy Steels:
AISI—4130, 4155, 52100

Stainless Steels:
AISI—303, 304, 309, 310, 316, 317, 321, 347, 403, 420, 430, 446, 502 (T-1)

Nickel Alloys:
Nickel, "Monel", "K-Monel", "Inconel"

Beryllium Copper



For the instrument maker, Superior furnishes tubing in cut, multiple or random lengths, shaped to "standard" specifications—or your specialized designs. Flat and elliptical ovals for bourdon springs can be produced in any analysis shown in the accompanying table.

Superior Shaped Tubing Specification and Tolerance Sheets list all the shapes and sizes for which tools are prepared and in stock. While the specification sheets are not available for general distribution, a Superior representative will gladly call at your office to review your dimensional, analysis and delivery requirements.

You are invited to make full use of this Superior service—your request will receive prompt attention.

See our tubing display booth No. 2527 at the 31st National Metal Exposition, October 17th to 21st, Cleveland, Ohio.

Superior

THE BIG NAME IN SMALL TUBING (.010" TO 5/8" O.D. MAX.)

SUPERIOR TUBE COMPANY

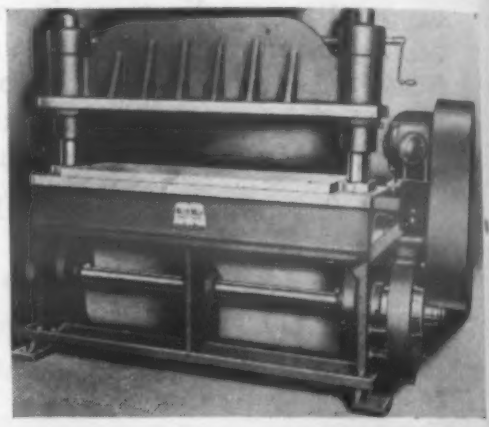
2006 Germantown Ave., Norristown, Pa.

For Superior Tubing on the West Coast, call PACIFIC TUBE CO., 5710 Smithway St., Los Angeles 22, Cal. • ANgeles 2-2151

New Materials and Equipment

Large Bolster and Ram Areas Featured on New Punch Press

The 30-ton Multi-Max Punch Press, Model 3048, manufactured by the *Diamond Machine Tool Co.*, Los Angeles, combines large bolster and ram areas, made possible by a new compact design with the underneath double crank drive mechanism. Ordinarily the larger bolster and ram areas are featured only on large punch presses and straight side presses.



Underneath double crank drive mechanism is key to design of this Diamond Machine Tool Co. punch press.

The bolster area of 16 by 48 in. and ram area of 10 by 48½ in. are said to make possible a wide variety of economical stamping operations, including blanking, piercing, notching, bending, shearing and drawing. The new punch press can also be used for cutting felt and fiber material with the use of steel rule dies.

The new design is intended to reduce manufacturing costs as compared with those for open-back inclinable and straight side presses of the same bed and ram areas.

Improved Cleaner Developed for Zinc-Base Die Castings

The *Pennsylvania Salt Mfg. Co.*, 1000 Widener Bldg., Philadelphia 7, has announced an improved cleaner, known as Pennsalt Cleaner Z-54, for reverse current cleaning of zinc-base die castings prior to electroplating.

Designed for use after a pre-cleaning operation such as spray-washing, emulsion cleaning or vapor degreasing, Z-54 can be used at solution temperatures averaging between 180 and 190 F, thus improving cleaning action.

Every sparkle means a farmer's saving money
You see them everywhere . . . farm roofs of Alcoa Aluminum
Because ALUMINUM LASTS

Wherever autumn highways take you, you'll see sun bouncing off a better kind of farm roof. It's Alcoa Roofing Sheet. It's light, easy to put on. Keeps buildings cooler inside. Best of all, it lasts.

It's successful because of a kind of partnership. Between American farmers, who see a bargain in a roof that lasts . . . and Alcoa, who spent years to make it possible.

In those years we brought the price of aluminum down to where an Alcoa Aluminum roof would fit a farmer's budget. Developed corrosion-resistant alloys that never need painting. Pioneered the kind of nails needed to put the roofing on. Tested finished roofs in all kinds of weather.

That kind of work enables us to say "Alcoa Aluminum lasts!" . . . and back it up. It makes things of Alcoa Aluminum worth buying.

ALUMINUM COMPANY OF AMERICA, 660J Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in principal cities.

ALCOA **FIRST IN ALUMINUM**
THE METAL THAT LASTS

SYNTHETIC SAPPHIRE *for*

Resistance to Wear

Outlasting hardened steel and cemented carbides 2 to 5,000 times.

Resistance to Friction

Affording very low friction surfaces due to hardness and surface continuity.

Resistance to Heat Distortion

Retention of form at temperatures up to 1,000°C.

Retention of Insulating Properties

Excellent dielectric properties over a wide range of temperatures.

LINDE Synthetic Sapphire is available in a variety of forms. It can be polished by flame or ordinary diamond polishing; it can be formed and bent by flame. Polished sapphire surfaces keep free of dirt, and in many anti-friction applications, need not be lubricated.

The experience that LINDE engineers have in applying sapphire to industrial processes may be of help to you. Call or write the LINDE office nearest you. Get your copy of the "Synthetic Sapphire Data Sheet", and the "Synthetic Crystal Stock List" of forms available.

Linde
Trade-Mark

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd St., New York 17, N.Y. Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The term "Linde" is a trade-mark of The Linde Air Products Company.

New Materials and Equipment

Portable Spot Welder Has a Variety of Uses

A portable and self-operating spot-welder for light gage work has been introduced by the *Greyhound A.C. Arc Welder Corp.*, 606 Johnson Ave., Brooklyn 6, N. Y. It is considered useful for plant maintenance shops and for use by manufacturers of blowers and ventilating systems, skylights, neon display fixtures, wire fences, kitchen equipment, and other fabricators of metal products.

The welder is light in weight—about 23 lb.—and is protected by a cast aluminum housing. Its transformer is wound with double spun-glass insulated magnet wire. The core of the transformer consists of high grade electrical silicon steel.

The spring attachment in the handle of the new portable spot welder includes a time saving feature. Removal of finger pressure from the handle automatically opens the welding tongs.

Available in both 110 and 220 v., a.c. models, 50 to 60 cycles, the portable tool equipment welds up to ⅛-in. combined thickness of metal, including stainless steel and mild steel, as well as up to 2 pieces of 18-gage galvanized.

Good Casting Characteristics Claimed for Liquid Plastic

A new liquid plastic, known as Glasy-Cast, featuring stability, good casting characteristics, and near-water-white color has been announced by *Ralph Travers*, chemist of Boston, Mass. The new material is said to produce castings of uniform consistency.

Composed basically of a polyester resin, and not intended to replace granulated resins as a production material, Glasy-Cast is claimed to provide an inexpensive means for a manufacturer to make up several hundred samples for market and performance testing purposes before making expensive molding investments.

As an aid in the use of his casting plastic, Travers has also developed a new molding compound called Elasto-Mold which is said to enable quick and cheap production of accurate molds.

The following physical properties of the new liquid plastic have been announced: color, clear and water-white; ultimate tensile strength, about 9000 psi.; modulus of elasticity, 532,500 psi.; shrinkage in curing, 7 to 8%; hardness, 45 to 50 Barcol; good insulating electrical properties.

One unit in Bethlehem's battery of forging equipment, which ranks with the best in the country.

Bethlehem offers every facility for the making of closed-die forgings

Do you want carbon steel for your closed-die forgings? Or does an alloy better suit your needs? Bethlehem can give you either. And Bethlehem can handle the die-sinking job, and of course the forging. Our shops are equipped with steam and board drop hammers, 1500 to 8000 lb; mechanical presses to 2000 tons; upsetters 9 in. and smaller. Heat-treating? Sure . . . in the most modern, efficient types of furnaces. Inspection? Thorough.

It's an all-around service that begins with the making of the steel and omits nothing. We think you'll like the competent way in which Bethlehem takes care of you. Let us quote on your business when you are next in the market.

★ BETHLEHEM STEEL ★

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

Whatever you COMPARE with a Forging ACTUALLY EMPHASIZES the METAL QUALITY OF FORGINGS

Macro-etch through longitudinal cross section of crankshaft shows flow lines or fibre like structure that is common in high quality forgings.

A REFERENCE BOOK ON FORGINGS
FOR ALL USERS OF METAL PARTS

Sixty (60) pages of authoritative information on metal quality as developed in forgings formed through the use of closed impression dies. Forging production techniques are described and illustrated; economic advantages of forgings are presented from the viewpoint of top management, design engineers, metallurgists and production executives. Your copy is ready. Fill in and attach coupon below to your business letterhead.

The uniformity of metal quality found in forgings cannot be duplicated! Now is an excellent time to check your product for cost reductions right down the line—explore every possibility to improve performance and appearance, while reducing dead weight of component parts. Double check all parts—particularly those which are subject to the greatest stress and strain. Check machining and finishing time schedules—forgings have been known to speed up production by as much as 250 per cent. Rejects at the point of assembly are costly, a needless waste—forgings offer almost a 100 per cent yield of sound parts because forgings are unusually free of concealed defects. Check to see if some parts may not be combined into integral forgings—an obvious saving in finishing operations. Consult a forging engineer when checking parts—only a forging engineer can inform you fully regarding the many advantages obtainable with forgings.

DROP FORGING ASSOCIATION
605 HANNA BUILDING
CLEVELAND 15, OHIO

DROP FORGING ASSOCIATION
605 Hanna Building • Cleveland 15, Ohio

Please send 60-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metal", 1949 Edition.

Name_____

Position_____

Company_____

Address_____

New Materials and Equipment

Wide Range Oven Design Changes Improve Furnace Flexibility

Additional furnace flexibility as a result of two design changes in the Sunbeam Stewart Wide Range Oven has been announced by the *Sunbeam Stewart Industrial Furnace Div. of Sunbeam Corp.*, 4435 Ogden Ave., Chicago 23.

Quick conversion of the furnace from semi-muffle to full muffle for atmosphere

The new Sunbeam Stewart oven can be converted quickly from semi-muffle to full muffle.

hardening is made possible by an inverted muffle section. A removable rear plug permits center heating of long bars.

The new design of the combustion chamber plus the location and 95% turn down ratio of the nozzle-mixing burners provide high turbulence to the combustion gases, making possible a temperature range of 300 to 2400 F for the unit.

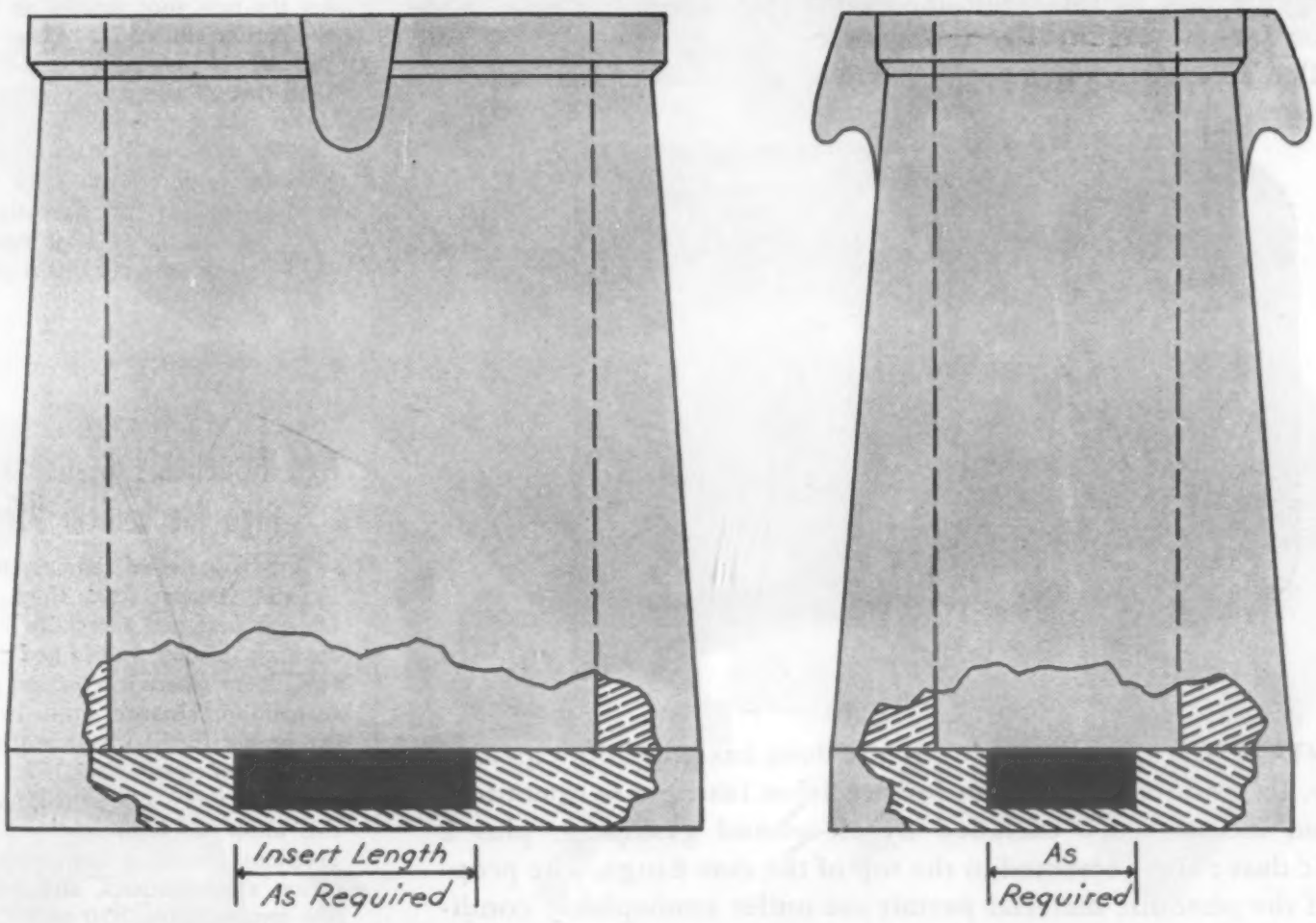
Safety, Low Cost Claimed for Synthetic Emulsion Degreaser

A synthetic emulsion degreasing agent, intended for use in standard cleaning equipment, has been developed by *Bee Chemical Co.*, 13799 South Ave. O, Chicago 33.

The new product, called Mulsolv, is designed to remove grease from metal parts prior to assembly or preliminary to preparation for shipment. It is non-toxic and also non-irritating to skin or nasal passages. Absence of scum, negligible corrosion of cleaned parts, and low cost are other advantages claimed for the new product.

NO MORE STICKERS!

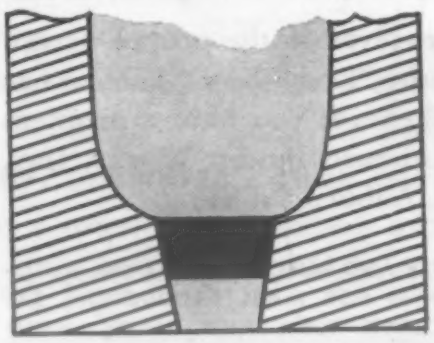
...when you use "NATIONAL" graphite stool inserts!



Use "National" graphite stool inserts in your open-bottom molds and you *eliminate stickers completely and forever!* Other advantages of graphite stool inserts are:

- They increase stool life by a wide margin
- Fewer stools are required — lower foundry costs
- They resist erosive action of falling molten metal

For more information on "National" graphite stool inserts, write to National Carbon Company, Inc., Dept. MM.



The term "National" is a registered trade-mark of
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.
Division Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

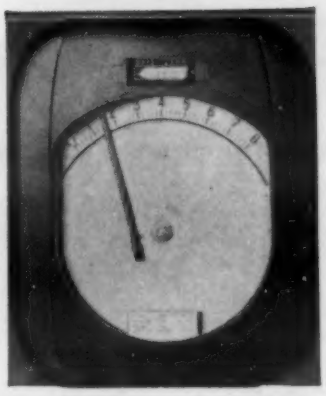
If you use plug-bottom molds, "National" carbon mold plugs save dollars. They last longer . . . weigh less . . . are truer to shape . . . won't stick, spall, or contaminate the ingot. Write us for complete details.

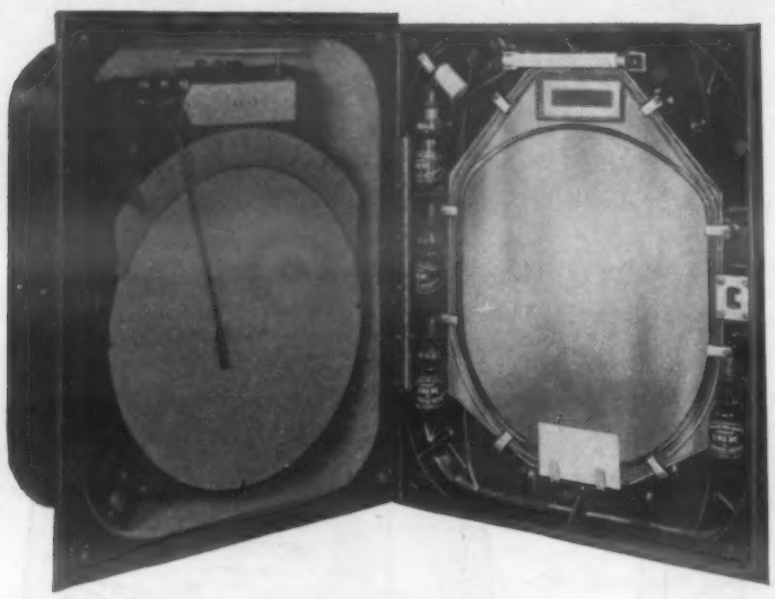
THESE PRODUCTS SOLD IN CANADA BY CANADIAN NATIONAL CARBON COMPANY LTD., TORONTO 4, CANADA

WHAT'S NEW IN AUBURN Plastics

A molded door for instruments manufactured by Penn Industrial Instrument Corporation of Philadelphia.

Molded from an impact type phenolic material, the 16" x 20½" door of this Hays-Penn Flow Meter was designed by Penn and Auburn. It weighs 3½ pounds. Internal bosses provide bases for mounting a fluorescent light, ink bottle holders, and the gasketed glass panel. A molded insert, reducing the size of the opening, adapts the door for use on the Penn Recorder-Controller, an entirely different instrument.





ADVANTAGES: Ribbed for strength, the door has good dimensional stability. Its flatness is important for precision instrument operation. Dust and moisture are excluded by all-around gasketing, plus a phenolic dust cover cemented to the top of the case flange. The properties of the phenolic material permit use under atmospheric conditions that would attack metals and finishes; the door serves as an insulating base for the electrical circuits it contains. No surface finishing is required; the smooth semi-matte surface is obtained in the molding process.

Successful solution of the problems involved in the proper design and production of this piece is typical of the "know-how" Auburn has developed in 73 years of experience. Whenever you have a problem in plastics, write Auburn Button Works, Inc., 410 McMaster St., Auburn, N. Y.

COMPRESSION, TRANSFER AND INJECTION MOLDING, AUTOMATIC ROTARY MOLDING FOR MASS PRODUCTION, EXTRUDED VINYL OR ACETATE TUBES AND SHAPES, MOLD ENGINEERING AND COMPLETE MOLD SHOP

Engineered Plastics

MOLD MARK

Auburn Button Works, Inc.

MOLDERS SINCE 1876 • AUBURN, NEW YORK

New Materials and Equipment

Many Advantages Over Chilled Iron Claimed for Steel Shot

A new fully heat treated true steel shot designed for use in all types of blast cleaning equipment has been announced by *American Wheelabrator & Equipment Corp.*, Mishawaka, Ind.

The following advantages are claimed for the new shot, known as Tru-Steel, over the earlier chilled iron abrasives: (1) Useful life of the steel shot is much longer than that of the chilled iron; (2) it wears down instead of breaking down—thus eliminating the possibility of fragments imbedding in soft work; (3) wear on blast cleaning equipment is greatly reduced; (4) cleaning rate is at least equal to that of chilled iron; and (5) cost per ton is less.

Age-Hardenable Stainless Steel Has High Mechanical Properties

A new grade of stainless steel developed by the *Armco Steel Corp.*, Middletown, Ohio is designed especially for gears, cams, shafting, chains, valves and pump parts in equipment where mechanical properties and corrosion resistance must be higher than can be obtained with present standard hardenable grades.

Called Armco 17-4 PH Stainless Steel, this alloy has high hardness and strength, excellent corrosion resistance, good fabrication characteristics, and requires only a low temperature (850 to 1000 F) hardening treatment. Its composition includes 17 chromium, 4 nickel, and 4% copper, giving it a corrosion resistance superior to that of the standard hardenable grades and approaching that of 18:8.

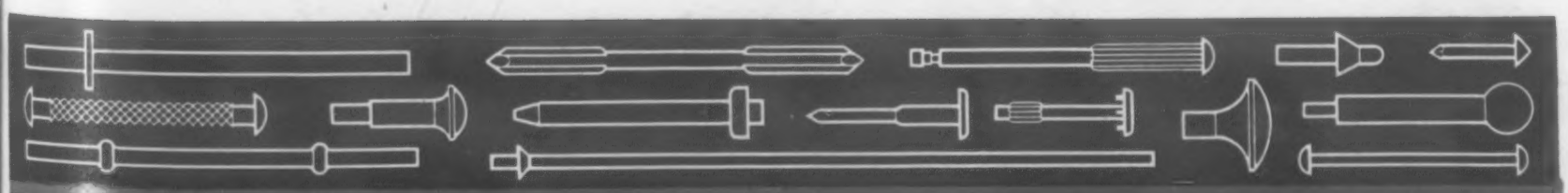
Hardness values of Rockwell 40 to 45C, with high tensile and yield strength, are obtained by precipitation hardening. This process involves heating the annealed material to approximately 900 F for about 1 hr., followed by air cooling. The relatively low temperature heat treatment is said to eliminate quenching cracks, distortion, internal stresses and objectionable scaling. Because only an easily-removed surface discoloration is produced in the precipitation hardening, parts can be finish machined before hardening, thus eliminating expensive grinding or finish machining normally required after heat treatment.

Readily hot-forged, machined and welded, Armco 17-4 PH Stainless Steel is available as bar and wire in either the annealed or hardened condition.

The trained hand of Hassall offers you:

SPECIAL NAILS·RIVETS·SCREWS
Hassall
ESTABLISHED 1850

HASSALL cold-heading may solve your immediate special part problem... Special nails, rivets and threaded parts made in diameters from 1/32" to 3/8"—lengths up to 7"... Rivets 3/32" diameter and smaller a specialty... also small threaded blanks ...Variety of metals, finishes and secondary operations... Economy, quality and quick delivery in large or small quantities... Your inquiries answered promptly... ASK FOR FREE CATALOG ...3-color DECIMAL EQUIVALENTS WALL CHART free on request.



JOHN HASSALL, INC. • 162 CLAY STREET • BROOKLYN 22, N. Y.

HEAT-
CORROSION-
ABRASION-
RESISTANCE

...OR
MACHINABILITY
IN

CASTINGS

by

Brake Shoe

● American Brake Shoe research and advanced foundry techniques can benefit you. When you refer your requirements to Brake Shoe, you get sound, clean, metallurgically correct castings, and machined rejects are low. You also receive the advantage of impartial recommendations as to metal types, such as:

Meehanite® — a series of controlled irons in 3 general groups to meet specific requirements; general engineering, heat resistant, corrosion resistant.

ABK Metal — a premium grade alloyed iron with outstanding abrasion resistance.

Engineered Gray Iron — a series of engineering cast irons with controlled properties and good machinability.

At Brake Shoe's large and well-equipped production foundries in Mahwah, N. J., Melrose Park, Ill., and Baltimore, Md., castings of widely used types can be made — light, medium or heavy weight, green or dry sand, or all core assemblies — as well as difficult or special purpose types.

Whatever your present or future needs for cast parts may be, send your specifications to Brake Shoe for expert recommendations.

AMERICAN Brake Shoe COMPANY

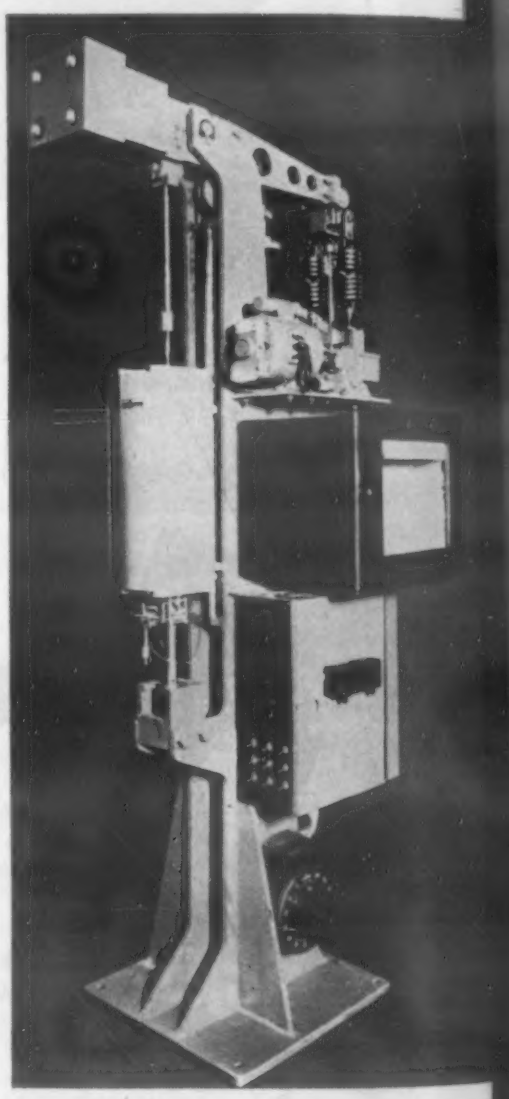
BRAKE SHOE AND CASTINGS DIVISION
230 PARK AVENUE, NEW YORK 17, N. Y.

New Materials and Equipment

High-Temperature Relaxation Tests Performed by Machine

Relaxation tests at temperatures up 1800 F, including a record of the rate decline of load, can be carried out au matically by means of a new machine 4000-lb. capacity developed by the *Baldw Locomotive Works,* Philadelphia 42.

Relaxation occurs when a material stretched to and held at a given elongati particularly at elevated temperatures. Cre then tends to elongate the bar and rele the load. This effect is balanced by elas shortening, and total strain remains co

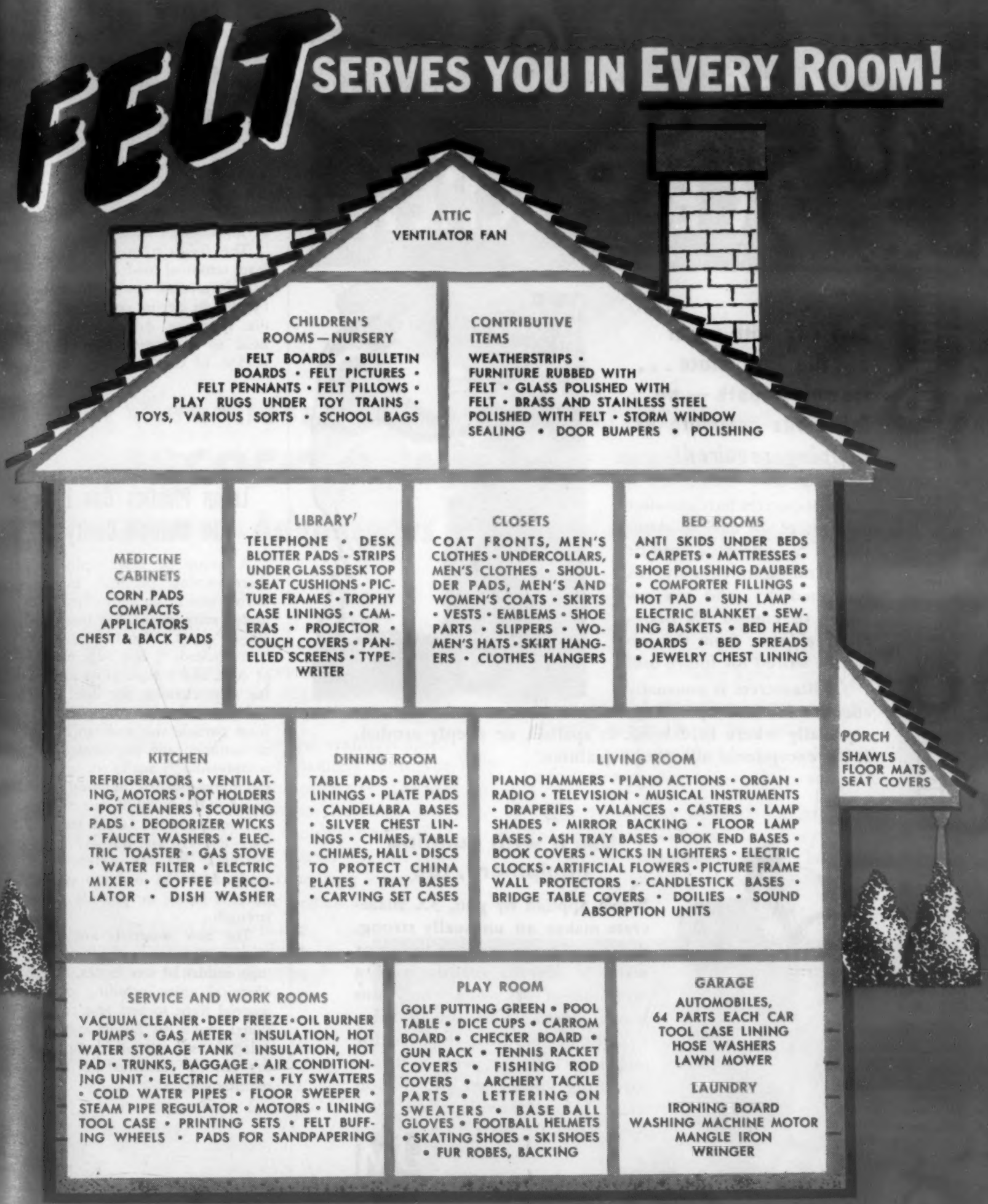


This Baldwin machine conducts high temperature relaxation tests automatically.

stant. The plastic elongation can be mea ured by the decrease in stress.

In addition to data on the behavior o metals at constant total strains, relaxatio tests establish the relative ability of a ma terial to withstand stress at high tempera tures. They are also valuable in estimatin creep values in certain ranges of stress an temperature for high strength alloys and in

FELT SERVES YOU IN EVERY ROOM!


ATTIC
VENTILATOR FAN
CHILDREN'S ROOMS—NURSERY
FELT BOARDS • BULLETIN BOARDS • FELT PICTURES • FELT PENNANTS • FELT PILLOWS • PLAY RUGS UNDER TOY TRAINS • TOYS, VARIOUS SORTS • SCHOOL BAGS
CONTRIBUTIVE ITEMS
WEATHERSTRIPS • FURNITURE RUBBED WITH FELT • GLASS POLISHED WITH FELT • BRASS AND STAINLESS STEEL POLISHED WITH FELT • STORM WINDOW SEALING • DOOR BUMPERS • POLISHING
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GOLF PUTTING GREEN • POOL TABLE • DICE CUPS • CARROM BOARD • CHECKER BOARD • GUN RACK • TENNIS RACKET COVERS • FISHING ROD COVERS • ARCHERY TACKLE PARTS • LETTERING ON SWEATERS • BASE BALL GLOVES • FOOTBALL HELMETS • SKATING SHOES • SKI SHOES • FUR ROBES, BACKING
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LAWN MOWER
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WRINGER

There are uses for felt in every room of your house. Look about you when you go home. There may not be much felt visible, for outside of such obvious uses as slippers, pads and chest linings, felt serves in hidden ways, as in wicks to lubricate motors, seals to keep out dust. Felt does not call attention to itself. It is silent, long-lasting, available in many different characteristics, adaptable to an infinitude of tasks. Are you making full use of felt in your plant and product? Write on your letterhead for "The Story of Felt."

American Felt Company

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GENERAL OFFICES: 24 GLENVILLE ROAD, GLENVILLE, CONN. PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

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HOW TO REDUCE YOUR REFRACTORY MAINTENANCE COSTS...

with the new

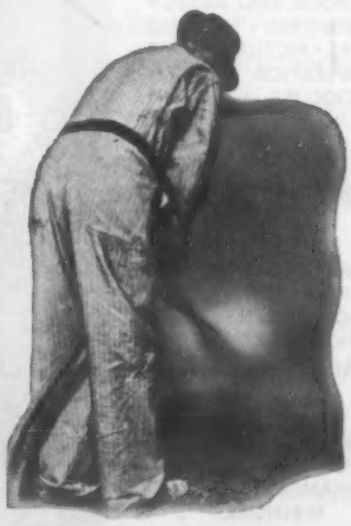
3X BLAZECRETE

3000° F

Just mix with water ... flip into place ... trowel smooth — *no laborious ramming or tamping required!*

3X Blazecrete hardens after 6 hours of air curing. After that, it can either be fired or left standing indefinitely. It's furnished dry, and any unmixed or unused 3X Blazecrete left over from the job can be stored for future use!

3X Blazecrete is unusually effective for heavy patching, especially where brickwork is spalled, or deeply eroded. It has exceptional adherence qualities.



Use it with gunning equipment, too

When applied by gun, 3X Blazecrete makes an unusually strong, dense and homogeneous lining or wall. It adheres readily with a minimum of loss when "shot" into place. Available in 100-lb bags. 155 lbs per cu. ft. is required for gunning; 130 lbs per cu. ft. for troweling. For further information write Johns-Manville, Box 290, New York 16, N. Y.

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Johns-Manville

3X BLAZECRETE

for patching and gunning

New Materials and Equipment

predicting mechanical properties of metals at high temperatures.

The Baldwin machine automatically relaxes tensional loads from as high as 40,000 psi., permitting strain increments of only 2 by 10^{-6} in. per in. on the standard 0.356-in. dia. specimen. Accuracy of the machine is held to approximately 1% of load or 0.25% of capacity.

Luron Plastics Can Be Formed in Multiple-Cavity Molds

A group of new medium-high impact thermosetting phenolic materials, named Luron, which can be molded on high speed, multi-cavity molds, has been announced by *Rogers Corp.*, Manchester, Conn.

An unusually low bulk factor, a fast rate of cure, and a high gloss finish after molding are claimed for the new materials. Clean and dustless, the plastics have a uniform particle size and can be easily poured or automatically pre-formed. They can be compression, transfer or plunger molded, the recommended molding pressure range being 4000 to 6000 psi.

Two grades of Luron are in commercial use—RX-416 and RX-418, both made only in black. RX-418 differs from its companion material in that a stronger cellulose fiber is used to provide greater impact strength.

The new materials are being used for large components such as transformer housings, industrial tote boxes, and a variety of electrical units including outlet boxes, industrial light sockets and coil forms. Additional grades of Luron are now being developed, and special formulations and colors can be furnished to meet individual requirements.

CORRECTION

The courtesy credit accompanying the photograph on page 69 in the July 1949 issue of MATERIALS & METHODS was in error. The oven shown there was built and installed by the J. O. Ross Engineering Corp.

Seamless Tubing Production Line at

THE BABCOCK & WILCOX TUBE COMPANY

Demonstrates Advantages of Speed-Heating with GAS

CONTINUOUS REHEATING of seamless tubing, at production speeds integrated with piercing-mill and sizing-mill capacities, demonstrates some of the important advantages of high-speed heating with GAS.

Many types of carbon, alloy and stainless steels are used in the manufacture of seamless tubing at The Babcock & Wilcox Tube Company. During the early stages of tube formation the tubes drop in temperature before entering the sizing mill. The modern Gas-fired units in the Beaver Falls, Pennsylvania, plant perform this reheating operation at speeds up to 162 FPM for 6-inch tubing.

Another important factor is the precise temperature control which permits adjustment of production speeds to compensate for delivery from the rolling mill or the requirements of the sizing mill. In addition, the automatic controllability of GAS permits immediate adjustment of temperatures for any type of alloy tubing.

Some of the results, attributed to this high speed GAS heating system by production executives of The Babcock & Wilcox Tube Company include—

- **fuel costs for reheating reduced 63% per ton**
- **output increased over 10% per hour**
- **product improved by absolute uniformity of heating**
- **maintenance costs reduced due to equipment simplicity**

The versatility of GAS for high-speed heating has been demonstrated in all type of production operations. It's always well to keep in touch with the latest developments in effective utilization of GAS.

Battery of twelve continuous Gas-fired Selas heating units in which seamless tubes, on way to sizing mill, are reheated from 1300F to 1900F and above.

AMERICAN GAS ASSOCIATION

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You reduce your cutting costs

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Type 304—Abrasive cut edges; machined faces. Weight 69 lbs.

Why waste expensive labor cutting odd shapes of stainless with improvised tools—when you can get just what you want from G. O. Carlson, Inc. cut to shape by our specialized equipment? And don't overlook the high cost of shipping unnecessary scrap material, which is eliminated.

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Carlson distributors are located in practically every metropolitan area. If you do not know your local source, write to us. If it is a rush order, send details direct. You can depend on G. O. Carlson, Inc. for unparalleled service in Stainless Steels.

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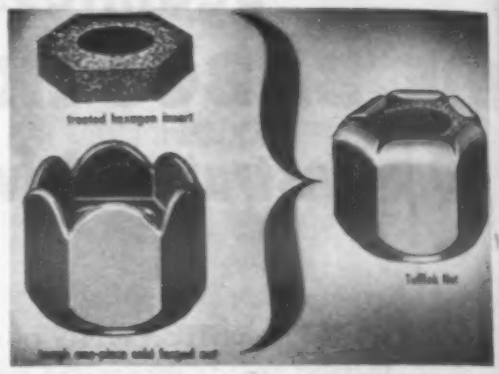
New Materials and Equipment

New Self-Locking Hex Nut Has Chemically-Treated Insert

A new self-locking hex nut with an improved insert is now being produced and sold by the *Townsend Co.*, New Brighton, Pa., under patents of the Nylok Corp. of New York.

The Townsend Tufflok Nut features a hexagonal locking insert intended to assure a tight grip at all times. The insert is



This Townsend Co. nut is strengthened by a specially-treated insert.

chemically treated to resist both absorption of moisture and drying out, which cause nuts to loosen. The cold-forged body plus the durable insert provide a tough nut which is said to exceed rigid Army-Navy requirements for aircraft fasteners.

The Tufflok Nut is available in sizes 4 through ⅜ in.

Portable Instrument Measures Coating Thicknesses on Steel

A simple, durable instrument for measuring the thickness of nonmagnetic coatings on carbon steel or iron has been announced by the *Lea Mfg. Co.*, Waterbury, Conn.

The Lea Lectromag is capable of measuring coatings from 0.0002 to 0.008 in. with ± 10% accuracy for thicknesses of 0.001 in. and over, and ± 15% accuracy for thicknesses under 0.001 in. The compactness and portability of this instrument are said to make possible on-the-spot thickness measurements.

Essentially, the Lectromag consists of (1) a 5-in. solenoid encased in a plastic holder; (2) 3/16-in. dia. glass tube with indicating scale; (3) soft iron core with marker within this tube; and (4) suitable leads and connection.

VANADIUM

FOR WELDABILITY

WRITE US FOR DATA ON THE SUPERIOR
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VANADIUM CORPORATION OF AMERICA

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CHEMICALS
AND METALS

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- *long time favorite with manufacturers of marine fittings . . . . . .*
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Soda Ash...Bicarbonate of Soda...Liquid
Chlorine...Dry Ice...Chlorine Dioxide...HTH
Products...Fused Alkali Products...Sodium
Chlorite Products...Carbonic Gas...Sodium
Methylate

New Materials and Equipment

Cutting Lubricant Designed for Tapping Steel, Plastics

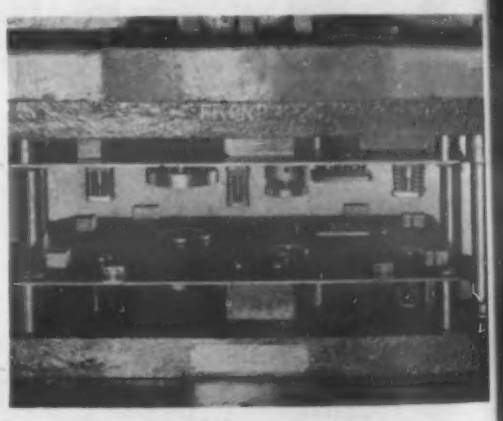
The *James L. McManus Co.*, 2121 S. Wabash Ave., Chicago, has announced a cutting lubricant, Aeromatic Tapping Compound, said to be of particular value in the tapping of steels, nonferrous metals, and plastics.

A special grade, 5-500, has been developed for the toughest stainless steels, such as 347. Good results from addition to screw machine oils in small percentages are claimed.

Piercing Operations Faster with Magnetic Punches, Dies

A faster way of making up die sets for the piercing of holes in materials up to and including ⅛-in. mild sheet steel has been announced by *S. B. Whistler & Sons, Inc.*, Buffalo, N. Y.

Whistler Magnetic Perforating Punches



This S. B. Whistler & Sons die set can be duplicated at any time in the future.

and Dies are assembled in a templet mounting plate. Upon completion of any job, the punches and dies, with their retainers, are quickly removable and ready for use in a new arrangement. The two templets are then stored and are all that is necessary to duplicate the original job at any time.

Forced Draft Laboratory Oven Maintains Uniform Temperature

The new Forced Draft "Isotemp" Oven developed by *Fisher Scientific Co.*, 717 Forbes St., Pittsburgh 19, for general lab-

(Continued on page 128)

YOU SAVE up to 30%

YOU DON'T PAY FOR SCRAP LOSS OR "REJECTS" WHEN

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MAKES ALUMINUM PARTS TO YOUR SPECIFICATIONS

NO SORTING OR SCRAP HANDLING

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Scrap and rejects require handling and shipping that sacrifice profits. When you use Reynolds production facilities, this scrap and reject metal goes back into remelt at the source... you never bother with it, you pay no handling charge.

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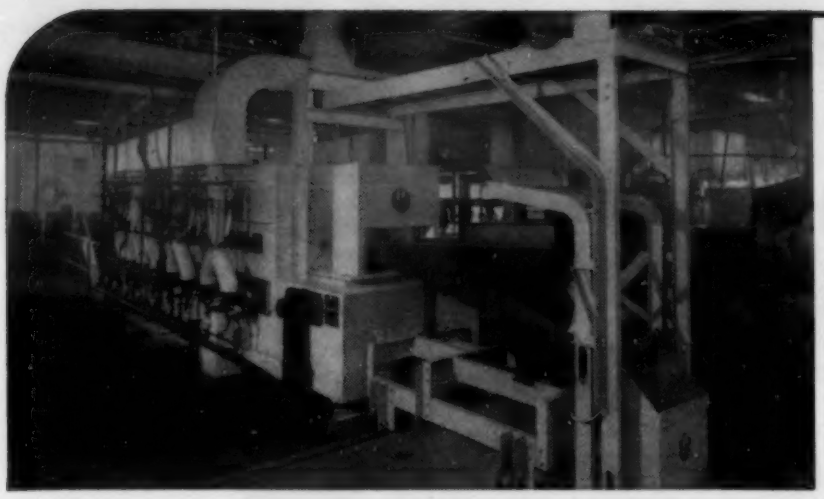

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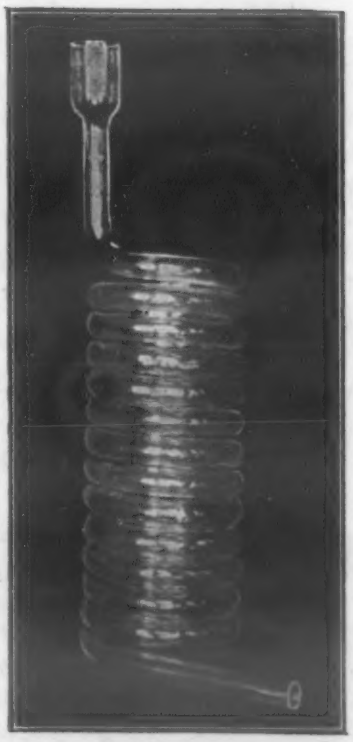
VITREOSIL (Vitreous Silica)

TRANSPARENT
(Vitreous Silica or Quartz Glass)



● Because of its extraordinary transparency to ultra-violet and infra-red rays, Vitreosil apparatus is particularly suitable for metallurgical investigations, physical, optical and electrical research where temperature conditions render the use of glass inadvisable. Transparent Vitreosil is unaffected by thermal shock, halogen gases and acids (except hydrofluoric and phosphoric) at any concentration or temperature . . . it is extremely hard, free from distortion and an excellent electrical insulator.

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New Materials and Equipment

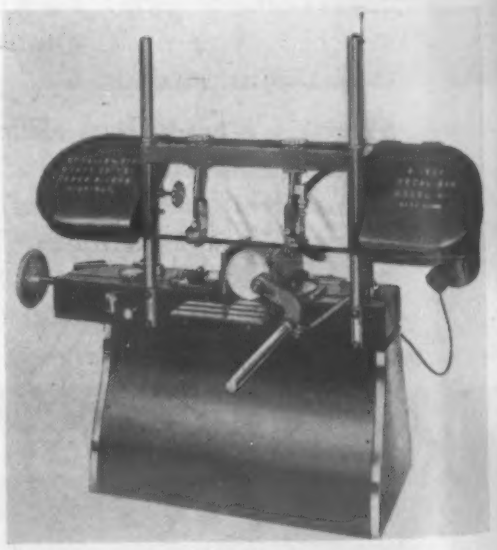
oratory use is said to perform drying operations in one-half to one-third the time required with a conventional gravity-type oven. The oven is said to maintain a selected operating temperature in the range 165 to 345 F within ± 1 deg.

Uniform temperature distribution throughout the 10 by 12 by 12 in. aluminum heating chamber is attributed to heavy glass wool insulation and a special arrangement of air ducts. Power consumption is 550 watts, the oven drawing current about 1/5 of the time after reaching the pre-set temperature. With heating elements embedded in a refractory material, the entire heating area is maintained at a relatively low temperature, and a latched pressure door is provided as a safety feature.

Tests on this forced draft oven, containing 400 sq. in. of shelf area, have shown that samples can be dried in about 90 min. as compared with 200 min. in a comparable gravity-type oven.

Milling, Planing Operations Handled by Metal-Cutting Saw

W. F. Wells & Sons, North on U. S. 131, Three Rivers, Mich., have started production of a new 9-in. metal-cutting band saw. Identified as Model M, the machine is



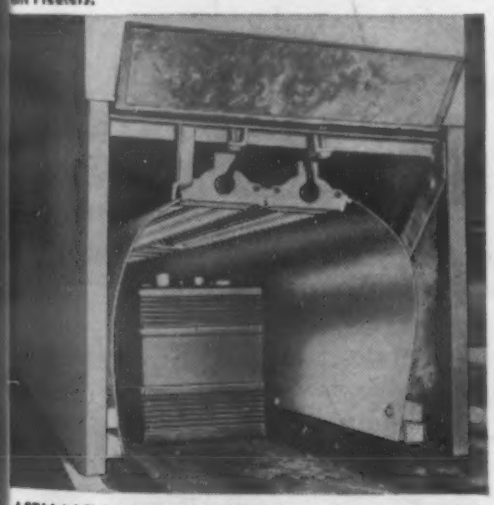
Slotting can be handled by this W. F. Wells & Sons metal-cutting band saw.

reported to fit the requirements of most cutting jobs. It is claimed to handle many milling and planing operations, such as slotting and removing corners of the blocks.

APPLICATION REPORTS from the CHROMALOX FILES

DEHYDRATING. Vari-colored powders for injection molding machines are completely and uniformly dried in 10 to 15 minutes with Chromalox Radiant Heaters.

METAL HEATING. Spherical molds containing compressed kapok are heated to 300° F. in one pass through a vertical oven formed with Chromalox Radiant Heaters.



ASPHALT-MELTING. Asphalt sealing compound is melted to provide proper "knit" between it and battery case. Bank of Radiant Heaters with variable control is installed in conveyor top. Side reflector sheets add efficiency.

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Electric RADIANT HEATERS

For INFRARED

- Drying
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and many other Applications

Quick, Low Cost Installation dependable service

FLEXIBLE! Easy to install in tunnels, single banks, double banks, ovens, etc. Gives infrared radiation in longer wave lengths which are absorbed almost equally well by all colors and textures of surfaces.

UNBREAKABLE! Rugged all-metal construction with aluminum body and shockproof, Inconel-sheathed CHROMALOX tubular heating element. Withstands shock, vibration, moisture and dust.

EFFICIENT! CHROMALOX tubular elements operate at 1400° F. Uniform, even heat—without "hot spots"—in low or high ambient temperatures. Units operate efficiently in all positions and at all angles.

COMPACT! Only 2 inches deep in nominal lengths of 2, 2½, 4, 5, 6 and 7 feet. Sections may be quickly interlocked to form their own oven, which can be further insulated for low, minimum heat losses.

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Electric heat for modern industry

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IC-45

EDITORIAL

Let's Unify

Unity of the Army, Navy and Air Force is now on about the first step of accomplishment. There is a good piece of climbing ahead before anybody can claim that unification is anything but a dream.

One of the first places where unification would be welcome would be in the specifications of materials. The least that could happen would be that much confusion would be eliminated in the minds of all those who deal with materials.

Let's take such a simple thing as a silver brazing alloy. There is one type which is known under these various specifications: USN 47S13c Grade IV; USA Chem. Warfare Serv. 196-131-80 Grade 4; USA Ord. Dept. (tent.) AXS-741, Grade 4; USAAF 11342, Grade B; Fed. QQ-S-561b, Grade 4; and AMS 4770. These are all for the same solder. In addition, the product also must bear up under the weight of its manufacturer's designation, and it just misses having an ASTM designation.

It would seem that one Government specification, whether civil or military, would be sufficient. But even if the Armed Forces settled on one specification and the Government civilian departments used another, we'd save at least three. That would be some improvement.

Maybe this same thing could be carried much further. For instance, we understand that many military repairs were delayed because of missing parts, when identical parts under a different part number were on hand. In those cases the fault was not entirely that of the Government. Many companies that use parts interchangeably on several of their lines of products gives each part a separate part number for each use. You'd be surprised how many numbers one simple little nut or cap screw might be buried under.

Today, all branches of the Armed Services are carrying on research programs. The competition most intense between the Navy and Air Force is the development of military aircraft. How much simpler, economical and practical it would be if the two groups would pool their knowledge and work together toward a common solution to the problem.

Thus, when unification starts in earnest, we would like to submit these as high priority items for unity and simplicity.

T. C. Du Mond
Editor